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SCIENTIFIC AMERICAN

SUPPLEMENT, No. 1790

Entered at the Post Office of New York, N. Y., as Second Class Matter.
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Published weekly by Munn & Co., Inc., at 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Scientific American, established 1845.
Scientific American Supplement, Vol. LXIX., No. 1790.

NEW YORK. APRIL 23. 1910.

Scientific American Supplement, $5 a year.
Scientific American and Supplement, $7 a year.

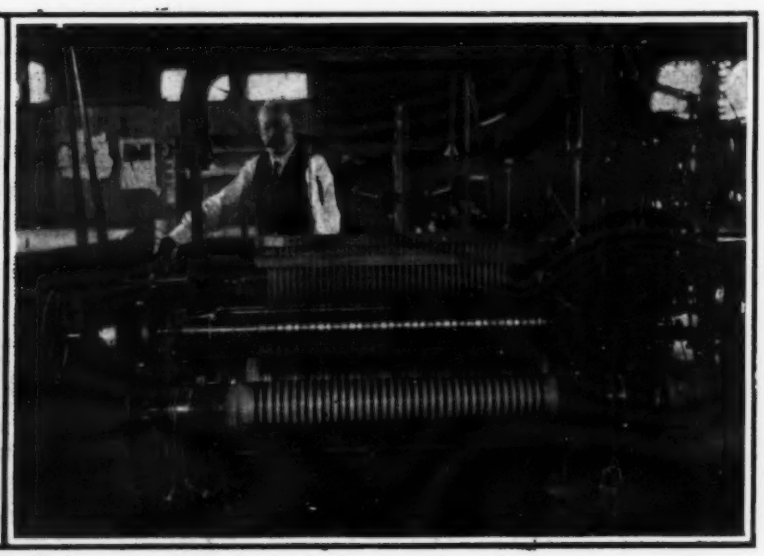
REELING SILK FROM THE COCOONS.

EXAMINING SILK AND REMOVING IMPERFECTIONS.

SOFT SILK WINDING.

WARPING.

QUILL WINDING.



REAR OF BOX LOOM WEAVING FOUR-COLORED CHECK. THIS HARNESS CARRIES 7,278 THREADS.

THE STORY OF SILK.—[SEE PAGE 264.]

BOILER CORROSION.

A STUDY OF ELECTRO-CHEMICAL ACTION.

IT is somewhat disappointing, says Engineering, that, with all our present scientific knowledge, there are certain phenomena in connection with the corrosion of steam boilers which, though they are perfectly well known and very troublesome, are due to causes which are not clearly understood. Many explanations have been given, and yet little really seems to be known about them. There can be no doubt, however, that they are due either to chemical or electrical action, probably to both. To what extent each of these is responsible for diseases, such as pitting, wasting, grooving, etc., to which boilers are liable, has for long been a matter provocative of arguments and discussions. Volumes have been written on the subject, and numberless cures, some of them, to say the least, ridiculous, have been advocated and tried. The diseases, however, still continue, and, in spite of all antidotes, remain a constant source of worry to the owner and to the engineer in charge. The high temperatures and pressures now in use have also increased their importance. It is, perhaps, more than can be reasonably expected that any certain cure should be found for these evils; and all that we can hope for is that they may be mitigated. Enough is, of course, known to enable us to do this, but it still remains that boilers deteriorate from causes which in some cases are most obscure.

It is, we believe, held by some authorities of high standing that all kinds of corrosion of iron, in whatever form, may be put down to electrolysis, or, as it is more commonly known among engineers, galvanic action. We are not prepared to indorse this fully, although there is no doubt that many forms of corrosion arise largely, if not entirely, from minute electric currents which are set up between different parts of boilers when in contact with water. It does not appear, however, that our knowledge is yet sufficient to enable us to say definitely that purely chemical action is free from blame. It may prove to be so, but more evidence is needed before we can be sure on this point. There is nothing new in this theory of electrolytic action. For years it has been regarded as an enemy to boilers, and has been combated in many ways, and who among us, with any experience of the working of boilers, does not know how firm is the faith of some men that plates of zinc attached by various ingenious methods inside boilers are a sure charm against corrosion. The theory of the action of these plates may at times be very vague in the minds of the users, but the fact that the plates waste away is often held to be a guarantee that in so doing they save the boiler itself. This is, no doubt, frequently the case, but, unfortunately, like many other so-called cures, zinc is not always successful. It is still quite possible, however, that electrolytic action has much to do with the corrosion of boilers. That it has escaped conviction is perhaps due to the difficulty there has been in obtaining absolute proof, though it has been easy to speak in a mysterious way of electric action when certain phenomena have puzzled us.

Now in order to have electrolytic action, it is, of course, necessary to have an electro-chemical system. In steam boilers we frequently have it, for therein electrodes of differing potentials may easily exist; nay, probably always do exist. For instance, in a locomotive boiler the shell may sometimes be the anode, and the tubes the cathode, the water being the electrolyte, while, under other conditions, the reverse may be the case, the tubes being the anode, and the shell the cathode, and it may take very little—a slight polarization possibly—to change the one into the other. The composition of the water also is an important factor. Probably in most boilers using ordinary water the iron of the boiler is the anode, and therefore wastes away. By the introduction of zinc, which is electro-positive to iron, the latter may often be converted into the cathode element and be preserved at the expense of the zinc. The copper ferrule, sometimes introduced between an iron tube and the tube plate, at once introduces a voltaic couple, the iron tube in this case forming the anode and becoming the victim of electrolytic action, which takes place in the form of grooving near the ferrule, or in pitting along the tube. A particle of carbon or cinder in the iron, which is electro-negative to that metal, may also set up this action, again at the expense of the iron, the result being the small pit-holes so often found where corrosion is in progress. It does not, however, appear to be necessary to assume the existence of two elements within a boiler; couples may be set up by the iron itself, for they may easily exist, particularly in the commercial form of that metal, and in the conditions accompanying its use. Previous physical treatment, internal strains, and inequality of temperature are probably quite sufficient to account for electrolytic action.

Bearing upon this subject, a number of very interesting experiments have recently been carried out by Prof. C. F. Burgess, of the University of Wisconsin, with the object of ascertaining whether similar corrosive results to those found in actual boilers could be produced by means of minute electric currents in a laboratory apparatus. The experiments were made with a small model boiler, means being employed to measure accurately the magnitude of any small currents that might be set up. The apparatus used consisted of an iron pipe 17 inches long by 7 inches in diameter, which had its ends closed by screwed caps, in each of which there was a hole provided with a stuffing-box, the holes being placed somewhat below the centers of the caps. These stuffing-boxes were provided so that an inner iron flue-tube, 1¾ inches in diameter, which was passed through the caps, could be insulated from the shell, and at the same time allow the joint to withstand a pressure of about 100 pounds per square inch. Asbestos packing was found to be most suitable for this purpose. On the upper part of the shell a steam-gage was fitted and a small cock for the release of the pressure; also a cock for the introduction of water. At the bottom of the shell was another cock for drawing off the water and sediment. A blast flame inside the flue-tube was used as a means of applying heat. Between the inside and the outside tubes electrical connections were made through electrical measuring instruments, consisting of a mil-ammeter and a mil-voltmeter. A large number of tests were carried out with this apparatus, the boiler being charged with different kinds of water, while various conditions as to heating and cleanness were employed. Prior to each run, or series of runs, on a given water, the interior of the boiler was thoroughly cleaned, after which 6,000 cubic centimeters (366 cubic inches) of water were introduced, allowing a steam space of about 2,000 cubic centimeters (122 cubic inches).

The tests showed curious results, particularly with regard to the variations of the electric current, these variations being in some cases somewhat unaccountable. In the first test referred to distilled water was used, and to this was added 3 grammes (9.27 drams) of amidol, the resulting solution being about 6,000 cubic centimeters (366 cubic inches) in amount. In all the experiments in which distilled water was used the water was produced under conditions that cause aeration, and air in boiler-water is usually regarded as an important factor, though to what extent it is deleterious is not very accurately known. As soon as the water was introduced (at ordinary temperature) it was noticed that the current suddenly rose to 0.075 ampere, but the flow was only momentary, and continued only for a few minutes, decreasing rapidly at first and then more slowly, till at the end of 260 minutes it was only 0.0085 ampere. What the cause of this was does not appear to be very clear, but Prof. Burgess thinks that it may have been due partly to polarization effect, both at the anode and at the cathode. This may possibly have accounted for it. The differences in the composition or previous treatment of the iron forming the inner and the outer tube respectively might, as he suggests, have been sufficient to cause the initial electromotive force which caused the current, while gradual polarization may have caused the decrease of the current that was noted.

When heat was applied to the inner tube, after the lapse of 260 minutes, the current again rose to a maximum of 0.067 ampere, which point was reached somewhat before the maximum steam pressure of 100 pounds per square inch was attained. This latter occurred about 306 minutes after the commencement of the test. From this point there was at first a rapid decrease in the current, which drop, however, soon became slower, and at the expiration of 440 minutes, when the source of heat was removed, it had fallen to just below 0.015 ampere. At this point a rather curious thing was noticed. When the heat was removed the current suddenly made a slight jump up, but at once fell off rapidly till it reached almost zero. This sudden jump in the current when the heat was shut off was, in fact, noticed during many of the experiments, independent of the kind of water contained in the boiler. The jump, however, was not always a sudden rise and then a drop, but sometimes a sudden drop and then a rise. As before stated, different kinds of water were used; in some cases the boiler being filled with pure distilled water, while different substances, such as pyrogallic acid, hydrogen peroxide, soda ash, and barium hydrate were introduced in small quantities, the soda ash in the proportion of about 1 pound per 1,000 gallons. In this case the effect of the soda was to increase the conductivity of the electrolyte, and to increase the current flow, which amounted at the maximum to about 0.044 ampere. This was considerably more than was noticed when distilled water was used. The voltage also was higher, reaching a maximum of about 0.100. With distilled water the maximum voltage was about 0.064.

A noticeable feature of the tests was that variations of pressure have little or no effect on electrolytic action, whereas temperature appears to influence the amount of current generated to a marked degree, and this was particularly observable in the case where soda ash was introduced into the water. If this chemical was employed in considerable quantities, it was found that the heated flue-tube became the cathode element, and the boiler shell the anode, and we believe that in actual practice this has been found to be the case, the shell being attacked by corrosion, and the tubes remaining free from it.

In order to test the apparatus under conditions as nearly as possible akin to actual practice, trials were made in which, after the boiler had been tested, it was allowed to cool down and stand for sixteen hours short-circuited, after which it was again tested while still containing the water supplied to it for the previous experiment. On being heated up again the current was found to be smaller than on the previous run; and on being cooled down again, and once more heated, the current was smaller still. In another case, after the apparatus had been allowed to remain short-circuited for forty hours, heat was applied. During the first half of this test it was found that for 160 minutes the current curve showed the flue-tube to be the cathode and the shell the anode, after which the opposite conditions existed, the flue-tube being the anode and the shell the cathode, although the current was much smaller than before. About 120 minutes after the commencement of the test the heat was removed and the steam pressure was allowed to fall off, though the apparatus was not permitted to become cold. In about 315 minutes from the commencement heat was again applied, and the current quickly fell to zero, and was then reversed, the flue-tube becoming once more the cathode. On the heat being again removed the current fell to zero. As to the corrosion that was noticed as a result of most of the tests, that on the flue-tube was found to be similar to the corrosion found in locomotive boiler tubes, incipient pitting being noticeable along the tubes, especially in the lower portion. At the ends of the tube a marked pitting was also found.

Without referring further to the many tests described, some of the facts which they appear to have demonstrated are well worthy of attention. Of course it may be said that the working of the small apparatus does not constitute sufficient ground on which to form a trustworthy conclusion as to what really takes place in large boilers. To take up this position, however, would, we think, be unwise. Much valuable information is often gained from such small experimental appliances, and, at any rate, the experiments we have described are worthy of very careful attention and of extended repetition. They, at least, demonstrate the possibility of marked electrolytic action. They also show that repeated heating and cooling promotes corrosion, which is also greatly influenced by the quality of the water and scale-preventing compounds used. Now if differences of temperature are responsible for a large portion of boiler corrosion, as the experiments seem to show, the problem would be largely an electrical one. How is this electrolytic action to be prevented? Largely, no doubt, by the use of pure water, but not altogether, because so long as the water is a conductor, so long shall we have electric currents formed, unless some other means can be found of preventing them. Even distilled water has some conductivity. If it were possible to prevent the heated parts of a boiler from making metallic contact with those parts that are not heated, a cure for corrosion might be found; but there seems to be no prospect of this. Under existing conditions it is doubtful whether anything more can be done than a reduction of electric currents to a minimum by careful attention to the composition of the water; and the experiments which we have discussed show that a certain amount of control can be introduced in this way, even to the reversal of the currents. Again, and this is a point to which Prof. Burgess calls attention, it may be possible so to distribute the electro-motive forces that the electric current is made to flow in such a direction that the more vital parts of the boiler may be protected. This has, of course, been done by the use of zinc; but this metal being rather costly, many boiler owners are reluctant to use it. The oxide formed by the decomposition of the zinc is also said to be an objection on account of its harmful effects as a scale-forming material. As a substitute it has been suggested to employ some other anode which will not have the disadvantages of zinc,

such as an iron bar made to take the place of one of the tubes in a locomotive boiler, and insulated from the rest of the boiler by some form of packing. This bar could be made to act as the anode by means of an electric current passing through it from some external source, and would, therefore, corrode in preference to the other part of the boiler. It might be quite possible to try this method, as the expense would not be great.

In conclusion, we may say that, valuable as we consider the experiments quoted, they form but a step on the threshold of the subject, and much must yet be done before there can be any feeling of certainty with regard to the electrolytic forces at work within a boiler. Prof. Burgess has shown clearly that such forces produce the forms of corrosion met with there, but he, or some other worker, has yet to discover where the sources of these electromotive forces are actually located. When this is done, and not till then, there may be some prospect of putting a stop almost entirely to boiler corrosion.

THE STABILITY OF SHIPS.

SOME MISCONCEPTIONS CORRECTED.

THERE is often much loose thinking, and more loose talking, concerning the stability of ocean-going steamers among those who ought to be better informed than the comments made sometimes seem to indicate. There appears to be a feeling abroad that ships are being built with too much upper work, too many decks, and too much top-hamper generally. It would be idle to deny that the modern ship is developing more and more in that direction, and that, to the uninitiated, appearances go against her. A constant demand for elevated accommodation by those passengers able to afford the luxury creates a corresponding supply, and the shipbuilder finds no difficulty in providing palatial structures of superimposed decks and tiers of cabins to satisfy it.

The result is often that such a ship, be she ever so handsome, has what is called a "topheavy" look. The word "topheavy" is a loose term to which we take exception. Topheaviness, if we understand it to mean either a lack of initial stability, or a deficiency in range of righting power, is not a question of height of ship out of the water only. A ship may be dangerously near instability in the upright condition with little or no height of upper works, and a certain height of freeboard is an absolute necessity if she is to have any range of righting power. So, then, we must look to all the conditions which combine to produce the state of balance usually termed the condition of stability, before founding a judgment as to a ship's qualities in this connection.

For convenience of thought we may assume a fixed displacement and draught of water, i. e., that of the ship in her loaded condition. For this there is a fixed height of transverse center of buoyancy, depending upon the vertical distribution of the displacement. It is, in fact, the position of the center of gravity of a homogeneous body of exactly the same shape as the immersed portion of the ship.

The height of the metacenter above the center of buoyancy for all moderate angles of heel is also a definite quantity, depending upon the form of the vessel, and it is readily calculable. For a fixed displacement and draught, which we have assumed, it is dependent wholly on the mean breadth of the water plane. These two factors, then, are quite definite, and the ship designer has no difficulty in knowing accurately their values. The actual power of the vessel to return to the upright when forcibly displaced from that position, however, depends upon the height of the metacenter above the center of gravity of the ship, and not primarily upon its height above the center of buoyancy. Here we are confronted with a less determinate quantity. The position of the metacenter relatively to any datum line, say the keel of the ship, is known from its height above the center of buoyancy; but we must know also the position of the center of gravity of the ship relatively to the same datum line before we can find the relative positions of the metacenter and the center of gravity, or the metacentric height as it is called, upon which the stability qualities of the vessel depend.

For war vessels and for fast passenger ships, carrying little or no cargo, the position is not difficult to estimate within quite small limits during the evolution of the design. In these, provided always that there be no serious change of disposition of weights, the final stability values for small angles of heel may be closely approximated to. The question of range of stability—meaning by this the possession of a force tending to return the ship to the upright—involves a longer process of calculation, but is just as definite. In warships with very low freeboard the range of stability may be comparatively small, even with a good initial stability; but in ocean liners the tall side gives a rapidly increasing righting power up to large angles of heel. This assumes that ports and sidelights are closed, all immersed parts watertight, and no weights shifted on board. In these cases, then, it is usually sufficient to ensure ample initial stability, knowing that this quantity rapidly increases with heeling.

From these considerations it will be seen that there should be no occasion for nervousness on the part of the traveling public, even where vessels have large numbers of superimposed decks, giving an appearance of top-heaviness. All the stability values should be known by the designer, and the same amount of righting power provided on a ship having many decks as in one having few.

There is an added consideration, however, in the former case, which does not hold in the latter, namely, the upsetting effect of a heavy wind blowing on one side of the high ship, and possibly blowing against the under sides of shelter and boat decks. It must be remembered also that passengers are not only high up, but that they usually all go to the leeward side when a beam wind is blowing. There is the further consideration also of the momentum which high superstructures have when the ship is rolling in a heavy seaway. The effect of position of passengers can be calculated and allowed for. Wind pressure and momentum are somewhat indeterminate, but naturally a ship designer makes ample allowance for these in fixing the metacentric height necessary for his ship. Experience has shown that for liners such as we are considering this should not be much less than 12 in., but for excursion steamers, in which the number of passengers is large, and their tendency is to go as high as possible, and often all to one side, the height may need to be 3 ft. or 4 ft.

But, it is asked, why not make the breadth of the liner a little greater, and so increase her metacentric height also, and obtain a margin of safety which will satisfy even the most timorous? That, indeed, is just the problem the designer of sea-going ships has to face. He is always between the Scylla and Charybdis of too little or too much metacentric height. Assuming that he have a free hand as to breadth of ship, which is not often the case, it would be fatal to the comfort of a passenger liner to give her too much initial stability, for that means a violent return to the upright at every heel caused by the waves, and consequently quick, heavy, and even dangerous rolling. A ship, to have seakindliness, must have only a moderate metacentric height, and in the cases mentioned this is easily determinable beforehand from past experience. To make quite sure, most shipbuilders make a test of the initial stability of every ship after completion by moving known weights across the deck a known distance, and noting the inclination of the ship produced thereby. From this, the righting moment is directly deducible, and the position of the center of gravity can be verified. There should, therefore, be no difficulty nor doubt in such a case as this, whether the ship have a top-heavy appearance or not.

The case for cargo steamers, and for those which carry passengers and a very considerable amount of cargo, is on a different basis. Here the problem is largely one of stowage. It is obvious that a ship carrying a certain deadweight may have that deadweight consisting of materials of varying density, and consequently the position of the center of gravity of ship and cargo in the loaded condition is a variable. The general rule is to calculate the metacentric height when the holds are stowed full of a homogeneous cargo and the coal and consumable stores are out of the ship. It is evident that if the stevedore have ordinary ability and freedom of action this will always be the worst position—that is, the center of gravity will be at its highest, and consequently the metacentric height least. If a fair allowance be made in this condition for initial stability, a ship of ordinary proportions should be absolutely safe as far as stability values are concerned. The question then becomes—how much latitude must one allow for want of knowledge or care on the part of those responsible for lading and working the ship? What are the possible contingencies that may occur? If, for instance, part of the cargo be of great density, such as lead, pig iron or rails, and for some real or imaginary reason this weight be stowed in a higher position than it should be, we have at once a condition not allowed for in the calculations and a consequent reduction of righting moment. Suppose, again, that the ship be fitted with 'tween-deck bunkers and the lower bunkers be emptied of coal before the upper ones are trimmed down into the lower position, we have a state of matters tending in the same direction. A ship so laden might be found to have a tendency to roll to one side or the other. It is possible that the captain, noticing this, would, to improve matters, order ballast tanks to be filled. During the process of filling quite a considerable time must elapse, during which there would be a free surface of water in the tanks, and this would temporarily add to the danger, although when the tanks were quite filled the righting moment would be increased. To obviate this, most modern ships of large size have ballast tanks which are divided longitudinally at the center line of the ship, by a vertical water-tight keel plate, and care is taken to fill only one or two tanks at a time.

In ships of well-deck type there is always a chance, when rolling, of shipping a heavy sea in the well. Such an influx is not immediately got rid of, and its weight would temporarily militate against the stability of the vessel. Of course, if by any chance a ship should get water into the holds or bilges through hatches or other openings, such free water would act detrimentally in the same direction, even if the quantity were inconsiderable as regards buoyancy.

It will be seen, then, that the safety of ocean-going steamers which carry cargo, from stability considerations alone, is more a question of management than design, and that, given a knowledge of the qualities of any particular vessel, with care in lading and handling, she should always be absolutely safe, for the designer will have allowed an ample margin of metacentric height for the service upon which she is engaged, from his accumulated data of other ships whose record has been good.

The general public is naturally uneasy when a large vessel with many passengers disappears absolutely, and leaves no trace, but that is no sufficient reason for at once dubbing the ship "topheavy" and blaming the design as being unsafe, on the assumption that the cause of loss is what is popularly known as turning turtle.

The late Professor Elgar once said, "It often diverts attention from the main cause of loss to say that it occurred because the ship was unstable. The fact is that the ship has frequently so little to do with the matter and the stowage so much that it is the latter which should be blamed for the instability and not the ship herself."

While that is perfectly true, it will probably do little or nothing to allay any uneasy feeling which may exist. At the same time it narrows the issue considerably to have a correct conception of the probabilities of any particular or suspected case of instability which may occur.

The plain procedure for owners is to have a full knowledge of the qualities of every vessel owned by them, and to lay down certain rules as to stowage of cargo with respect to position of center of gravity when fully laden, which may not on any consideration be departed from.

This is, of course, more easily said than done, for where large cargoes of mixed commodities have to be securely stowed by a fixed sailing date, and the stevedore has to deal with many ships, there is always a tendency to stow carelessly, and to give scant attention to the exact position of the center of weight. The captain of each vessel should, however, be the responsible man for that vessel, and surely a simple instruction could be given to him, which should be within his grasp, and enable him to satisfy himself before sailing, that the metacentric height is ample for all emergencies.—The Engineer.

In the first charge of a new ignition accumulator be not properly carried out its efficiency may be permanently impaired. Acid should be purest brimstone sulphuric diluted to s.g. 1.225 with distilled water. The acid should be added to water, and not water to acid, and the mixture should be allowed to cool before filling the cell. After the accumulator has been filled with acid it should be charged for at least thirty-six hours at about half the rate given on the label. If after thirty-six hours the s.g. of acid does not reach 1.225 or over, the charging should be continued until it does. After the first six charges it improves the capacity of a cell to empty out the acid—while fully charged—and refill with fresh acid of 1.225 s.g.

INTERESTING CAM CONSTRUCTIONS.

NOVEL MECHANICAL MOVEMENTS.

BY EDWARD PERSON.

WHEN designing automatic machines that are more or less complicated, it is not always possible to avoid the use of cams in order to accomplish the work for which the machine is intended. When several cams are to be used on the same machine, it is necessary to make up a cam chart from which the designer works when laying out the cams. This chart should give the stroke required for the mechanism and indicate what part of the revolution of the cam shaft is required to produce the required stroke, as well as the period of rest. These quantities are given in degrees.

Fig. 1 shows a cam chart for two cams, the curves being crank-motion curves. The first cam, starting at zero, moves the mechanism operated three inches, while turning 90 degrees. There is then a rest or dwell for 180 degrees, and a return movement in the remaining 90 degrees. The mechanism operated by the second cam rests until the cam has turned 90 degrees; the cam then imparts a motion of 2½ inches from 90 to 140 degrees. There is then a dwell for 50 degrees, a return motion during 70 degrees, and finally a 100-degree dwell on the low point of the cam.

The crank-motion curves on the cam chart are constructed as follows: Set off the stroke of the mechanism, three inches in the first case, and two and a half inches in the second. Construct a half circle with the length of the stroke as diameter, and divide the half circle into a certain number of equal parts. Also divide the length representing the drop and rise into the same number of equal parts as that into which the half circle has been divided. Then draw lines from the dividing points as shown in Fig. 1. The intersecting points will be the points of the curve. It is of importance that these curves be correctly constructed, as this provides for a smooth movement of the mechanism at any point during the revolution of the cam. Of course these curves do not need to be crank-motion curves, but can be changed to suit conditions.

Figs. 2 and 3 show the constructions of cams laid out from the first cam chart curve in Fig. 1. These cams are working positively in either direction. The construction in Fig. 2 consists of a grooved cam *A*, and a yoke *B* forked over the hub of the cam and carrying the roller *C*, placed in the groove. When revolving the shaft, the yoke, guided by a bushing at *D*, will move back and forth three inches in a straight line. For laying out the cam proceed as follows: Set off from the zero point on the cam in a direction opposite to that in which the cam revolves, 90 degrees, and from this point set off 180 degrees, and then another 90 degrees, which brings us back to the starting point. Determine the highest and lowest points on the cam, which in this case are located 8 and 11 inches from the center respectively. Set off at the lowest point (as shown at the top of the cam in Fig. 2) the radius of the roller and the stroke of the cam, which latter, of course, is the same as the difference between the highest and lowest points. Draw a half circle having the stroke for its diameter, as shown, divide the circumference of the half circle into the given number of equal parts, and draw perpendiculars from the division points to the diameter or base line. Then divide the angles for the rise and the drop into the same number of divisions as that of the half circle, and draw radii to the division points from the center of the cam. From the points where the perpendiculars intersect the base line draw circular arcs with the center of the cam shaft as a center until the arcs intersect the corresponding angular division lines. Take the points of intersection for centers and draw circles having a diameter equal to the roller diameter. The line tangent to these circles is the true crank-motion curve.

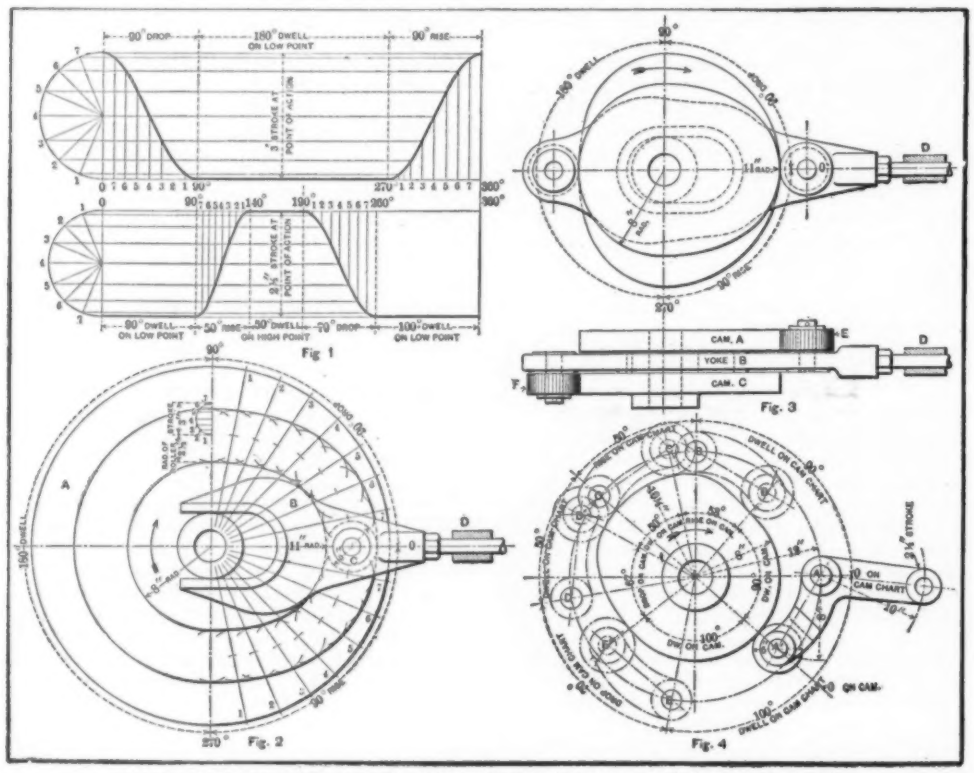


Fig. 1 Fig. 3

Fig. 2 Fig. 4

CAM CHARTS AND DIFFERENT METHODS OF LAYING OUT CAMS.

The second cam construction, Fig. 3, consists of two cams *A* and *C*, one on each side of the yoke *B*, and two rollers *E* and *F* mounted on each side of the yoke. The yoke in this case is also forked over the hub of the cams and guided at *D*. The cam curve for the top cam is identical with the inner curve in Fig. 2, and is laid out in the same manner, as is also the rise and the drop for the bottom cam. The only difference is that when the top cam has a dwell on the high point the bottom cam has a dwell on the low point, and *vice versa*. This, of course, insures a positive movement both ways.

Fig. 4 shows another cam construction laid out from the second chart in Fig. 1. It consists of only one cam, a lever and a roller. This construction is positive only one way and must be actuated by a spring for returning, but it can be arranged to work positively by making a three-arm lever, a return cam, and a return cam roller. The point illustrated in Fig. 4 is the variation of the angles of the cam, as compared with those of the cam charts, due to the rise and the drop of the roller on the end of its lever. Instead of turning the cam shaft in the direction indicated by the arrow, assume that we swing the center of the lever pivot in a circle around the center of the cam, but in the opposite direction to the cam motion. To lay out the cam, we must first assume the length of the lever, the stroke of the cam, and the highest and the lowest points on it. The center of the lever pivot, at the start, will be at zero on the cam chart, and the center of the roller will be at zero on the cam. From the zero of the lever pivot, Fig. 4, set off 90 degrees for the dwell on the low point, 50 degrees for the rise, 50 degrees for the dwell on the high point, 70 degrees for the drop, and then 100 degrees for another dwell on the low point. Draw radii from the center of the cam shaft to each of these divisions. Take the points where these radii intersect the circle along which the center of the lever pivot moves, as centers for circular arcs having the roller arm *AA'* for radius, as shown at *BB'*, *CC'*, *DD'*, and *EE'*. Then set off, from the center of the cam shaft, a distance equal to the radius of the cam plus the radius of the cam roller at each of these places (at *B'* the distance set off would be 8 + 2½; at *C'* 10½ + 2½, etc.). The points of intersection between these distances and the arcs struck with radii *BB'*, *CC'*, etc., are used for centers for circles having a diameter equal to that of the cam roller. Now it will be seen by measuring with a protractor, that where the dwell occurs the angle of the cam will be the same as the angle on the cam chart, but where a rise or a drop takes place the angles will be different. In the present case, the 50-degree rise on the cam chart and of the cam lever will be about 53 degrees on the cam, and the 70 degrees drop on the cam chart will be about 67 degrees on the cam. This is of importance when several movements are used, and one movement starts immediately after another in such a relation that one must come to rest before another starts. The curves for the cam can be laid out in a manner similar to that explained in Fig. 2.—Machinery.

BLOWPIPE METHOD FOR CUTTING IRON OR STEEL.

THE oxyhydrogen blowpipe process for cutting iron or steel is coming into use on an extensive scale in various countries of Europe. The following recent data will show some of the advantages which are obtained by its use, in the way of time and expense. An armor plate of 160 millimeters (6.3 inches) thickness is cut for a length of 1 meter (39.37 inches) in 10 minutes. For the same length, the cutting of a 15-millimeter (0.59 inch) plate requires less than 5 minutes and the cost of the operation is not over 1.50 franc ($0.30). To cut a manhole of 300 by 400 millimeters (12 by 16 inches) in a steel plate of 20 to 30 millimeters (0.8 to 1.2 inch) requires 4 or 5 minutes. A 6 by 16-inch hole for tubulure cut in a pipe of 0.2 inch thickness takes from 3 to 4 minutes, while the usual method of cutting requires from 35 to 40 minutes. The expense by the blowpipe method is from 2 to 3 cents. An interesting example of blowpipe work was carried on in Paris at the Metropolitan subway station, Place d'Italie. It was required to cut away an iron staircase of 6 meters (19.7 feet) height and to decrease the width, as the present width of 3.50 meters (11 feet 5 inches) hindered the circulation. Accordingly it was decided to cut off about 3 feet width of the whole staircase, and this was done within four hours' time. The small portion which had been cut off was also used as a staircase in another place and was in no way damaged by the operation. At the shops of the Northern Railroad Company there were cut out certain portions of the main longitudinal beams of a locomotive without dismounting the latter, and the cutting was done in two places. By the old methods this operation would have taken at least 3 days, but at present it was done in 25 minutes. The expense for the gas in this case was but $0.80. At Bremen, Germany, the new method has been used for demolishing vessels, and the following results were obtained. A steel plate of 300 millimeters (12 inches) thickness was cut for a length of 1 meter (39.37 inches) at a depth of cut equal to 4 to 6 centimeters (1.6 to 2.4 inches). This operation took 7 minutes. The same plate was cut by a pneumatic tool for 1.15 meter (3¾ feet) length and at a depth of only 1.5 centimeter (0.6 inch), and this took 1 hour to carry out. The blowpipe process was also useful for unriveting plates, and it was found that in less than 12 seconds it is possible to burn off the head of a 22-millimeter (0.9 inch) rivet without detriment to the plate. The rivet is then driven out by forcing. The greatest thickness of armor plate which has been cut up to the present is 210 millimeters (8.4 inches), but a thickness of 300 millimeters (12 inches) is reached in the case of round shafting. At the Lorient shipbuilding docks in France, holes are constantly cut of all forms in plating of 65 millimeters (2.6 inches) thickness, this plating being formed of three thicknesses riveted together, and is used for the decks of warships.

TUNNELS IN BEING AND TUNNELS TO COME.

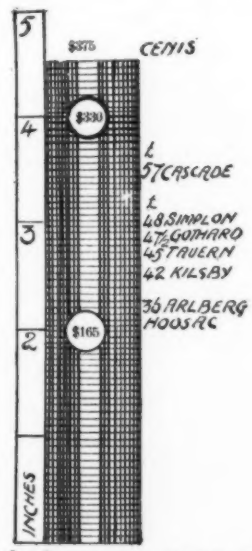
THE WORK OF THE BURROWING ENGINEER.

As NOVEMBER waned, the last few yards of tunneling necessary to link the far eastern and remote western sections of the Buenos Ayres and Pacific Railway were duly excavated. The occasion was particularly noteworthy, not only on account of the fact that the task accomplished represented a feat remarkable in an age accustomed to marvels of engineering, but because the way was cleared for the passage of the first through train from the Atlantic to the Pacific coast of South America, a journey that should be completed for the first time during the current year.

The Trans-Andine Tunnel, though not remarkable for its length (its two miles burrow is exceeded in linear measurement by ten tunnels in the United Kingdom alone) is distinguished, apart from its political importance, by the fact that the work was carried on at an elevation of 10,000 feet, which is, of course, 1,000 feet higher than Europe's most soaring carriage road, the Stelvio Pass, but rather more than 5,000 feet below the remarkable Galera Tunnel in Peru, whose drainage water runs from its eastern exit into the Atlantic Ocean, while that from the western mouth percolates downward until it mingles with the waters of the Pacific.

When the line is completed the traveler at Buenos Ayres desirous of reaching Valparaiso will have before him a railway journey practically coinciding in length with that between Calais and Rome, but rather more tedious one would opine from the fact that gradients of 8 per cent are encountered *en route*, entailing the use of the rack and pinion. Notwithstanding, however, the fact that the Trans-American route will most probably take longer than the thirty-six hours that the Calais-Rome journey entails, there is no doubt that the traveler will face the journey this year with far greater equanimity than in the pre-tunnel days, when he had the prospect of either being detrained at Las Cuevas and having to cross on mules a spur of the Piuquenes ridge to Caracoles, a path only open in the summer, or in winter of covering some 3,600 miles of ocean (say, from London to New York as the aviator will fly), including the especially troubled waters of Cape Horn. The saving in time and money that the tunnel will enable the winter traveler to make has been set down at twelve days and £13 respectively, but no appraiser has succeeded in estimating the gain in comfort.

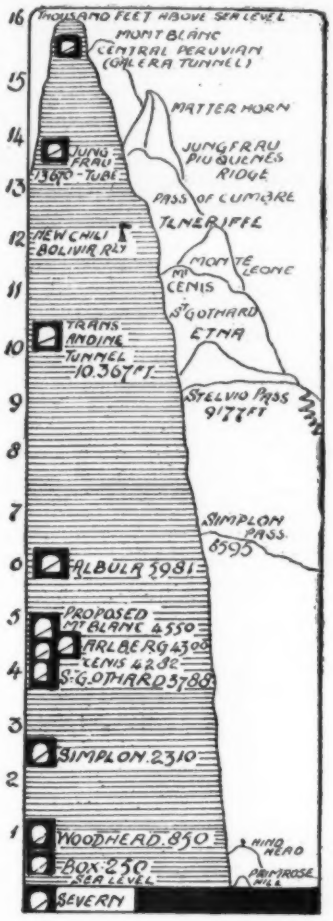
The latest of the mountain tunnels, it will be noted from the diagrams illustrating this article, is comparatively short as lengthy tunnels go, but to attain this desideratum it was necessary, and doubtless desirable, to pierce the mountain at a very considerable altitude, with the result that, in place of having 9,000 feet of mountain above it, as in the case of the Simplon Tunnel and Monte Leone, or between 6,000 feet and 7,000 feet in those of the Mont Cenis and Gothard tunnels, the Trans-Andine Tunnel pursues the even tenor of



THE COST OF SOME WELL KNOWN TUNNELS PER FOOT IN DOLLARS.

its way about 2,300 feet below the pass of Cumbre, which crosses the Argentine-Chili frontier at an altitude of 700 feet above the highest level to be attained by the new Arica (Chili) La Paz (Bolivia) Railway, whose 300 miles or so of permanent way the well-known firm of contractors, Messrs. Sir John Jackson, Ltd., have now in hand.

It has been put on record that the actual sum voted for the railway that is to join up "the highest city" in the world, La Paz, 12,000 feet (Sicuani, 14,666 feet, on the Southern Railway of Peru, cannot apparently claim the rank of city), with the Pacific coast is £3,000,000. If this amount represents the total con-



SOME ELEVATED TUNNELS.

templated outlay on a railway of 300 miles, a startling awakening would appear to be in store for the promoters of the scheme, judging from the figures provided by mountaineering railways on this side of the Atlantic. For instance, the most recently opened European railway, the Tauern system, formally inaugurated by the Emperor Francis Joseph last summer, which runs from Gastein in Salzburg to Spittal on the Drave (Carinthia), though only some thirty miles in length, cost twelve and a half million sterling to build, of which amount the great Tauern Tunnel, near Gastein, that took nearly eight years to build and is 5¼ miles in length, accounted for one and a quarter millions sterling.

Tunnels are very expensive luxuries even in the present year of grace, but they are nothing like so expensive as in the days of the Cenis excavation, when each yard linear cost $1,130, and the total cost was just about ten times the sum ($1,400,000) expended in the early years of the last century in making the road over the Simplon, a task that only occupied five years, notwithstanding the fact that 1,722 feet of rocky galleries had to be blasted, and 250 tons of gunpowder (as compared with 157 tons in the case of the Woodhead Tunnel, Great Central Railway) used for that purpose. The famous Simplon Tunnel, that occupied so much attention on its completion early in 1905, cost, all told, $720 a yard, a statement that can best be appreciated when it is realized that on some occasions there were 4,000 men working on it at once (the Trans-Andine authorities were content to employ half that number), that the bore holes numbered 4,000,000, the explosion caps a like number, the fuses aggregated 3,290 miles, or enough fuse to extend from Liverpool to New York, while, for the purpose of dislodging 35,314,800 cubic feet of *débris*, sufficient to cover a road 60 feet wide, to a depth of 1 foot, through 109 miles (London to Bath), 1,350 tons of dynamite had to be exploded.

At periodic intervals rumor asserts that the mighty Mont Blanc herself is to have a tunnel driven through her majestic proportions, for the purpose of linking Chamounix and Aosta, but up to the present date nothing has been done with respect to the scheme in question, apart from the preparation of M. Jacquier's plans, which indicate that the excavation would be 8½ miles in length, that the entrance at Chamounix would be 3,415 feet above sea level, and the exit at Entrèves 1,135 feet higher still.

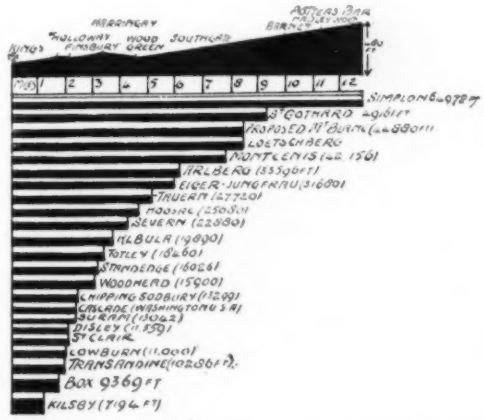
Not a hundred miles from Chamounix (fifty-five in point of fact), however, yet another lengthy tunnel is now being made, that, unless its name is changed for something with fewer possibilities in the way of pronunciation, is scarcely likely to attain conversational popularity in circles addicted to using the English tongue. The Loetschberg, to give it its local appellation, is to have as its "Goschenen" that singularly beautiful village Kandersteg at the foot of the Gemmi Pass, and the object of the tunnel and the line running through and in connection with it, is to provide a short cut from Calais and the north *via* the Simplon, to Italy in general and Brindisi in particular; the saving in distance over the present route being fifty-two miles.

The Loetschberg, which passes under the Balmhorn and might very well be named after it, on leaving Kandersteg burrows under the Kander River, and eventually comes into the light of day in the Lotschenthal; it then delves into the mountain again for a few kilometers, and, bearing round to the right, emerges in the Rhone valley, on the north side of which, parallel to the Swiss Federal line, it proceeds to Brigue, where it joins the Simplon line.

In addition to the Jaman Tunnel, on the Ligne Montreaux-Oberland-Bernois, that has a length of 8,125 feet, and an altitude (3,600 feet) rather more elevated than the summit of Snowdon, and upon which £18,000 worth of dynamite was expended; within the last few years a tunnel has been pierced between Lichtenstieg (sixteen miles southwest of St. Gall) and Utznach, that is rather over five miles in length, while a number of other central Europe tunnels have been projected, of which that through the Col de la Faucille, between Lons le Saulnier and Geneva, is the most important.

To the motorist the Col de Faucille is an eminence (4,300 feet) about seventeen miles from Geneva, which when attained by a 7 to 12 per cent rise presents exquisite views of the Alps and Mont Blanc prior to a descent, *en lacets*, of 7 per cent to Gex; to the railway engineer, however, the Col represents a nut to crack which would necessitate expending £4,500,000 on a tunnel nine miles in length that would be about 1,834 feet above sea level, and have a steepest grade of 1 in 100. The tunnel, it is estimated, would save 2½ hours on the journey between Paris and Switzerland, and would represent the first stage of the new and most direct route from England to Italy, *via* Chamounix, Mont Blanc, and Aosta, a route that would possess one great advantage, from the Gallic point of view, inasmuch as it would mean that the traffic would practically pass through French territory and over French systems from start to finish.—The Car.

Eddy currents or Foucault currents, as they are sometimes called, in honor of the man who first explained and described them, are very difficult to calcu-



COMPARATIVE LENGTHS OF SOME FAMOUS TUNNELS.

late, because they occur in closed circuits of their own selection in the mass of a metal, and are not restricted to definite wires or simple channels. Of recent years, however, a number of practically important cases have been successfully analyzed mathematically. A very attractive solution for the case of copper strips in the grooves of a simple alternating-current armature has recently been given by Dr. F. Rusch in Electrotechnik Maschinenbau.

THE GERMAN ARMY.*

ITS MERITS AND ITS DEFECTS.

BY RICHARD THIRSK.

THE German army is composed of the combined armies of Prussia, Bavaria and Saxony. Generally speaking, it might as truthfully be called the Prussian army, since nineteen of the army corps belong to Prussia, whereas Bavaria has but three, and Saxony only one. The total strength of these combined armies during times of peace is put down on paper at something over six hundred thousand officers and men, divided into six hundred and twenty-nine battalions of infantry, four hundred and ninety-five squadrons of horse, five hundred and seventy-four batteries of field artillery, forty battalions of fort artillery, thirty-four battalions of engineers, and sixteen machine-gun divisions. Besides these, there are the various necessary auxiliaries for serving such a large army, including the medical staff, the commissariat, the veterinary surgeons, and other non-combative forces. A bill passed recently by the Reichstag empowers the authorities to augment largely the number of men serving in the ranks.

The term of service in foot-regiments is for two years; in the cavalry and horse-artillery men must remain a year longer. From active service, soldiers pass into the First Reserve for a period of five years, during which they are frequently called up to their regiments for longer or shorter periods of drill. At the end of this time they pass into what is known as the Landwehr, or Second Reserve, and finally into the Third Reserve, in which they remain until the completion of their thirty-ninth year, when they are freed from military service.

While on active service the infantry soldier receives six shillings a month pay, the cavalryman two shillings more. Lieutenants begin with sixty-four pounds ten shillings a year, rising slowly through various grades to six hundred and ninety-nine pounds a year, which is the sum paid to commanding generals. To this must be added a small allowance for rent granted to officers who cannot be housed with their regiments.

The Kaiser is the Oberster Kriegs-Herr—that is to say, the supreme head of the army, whose approval must be obtained in all that concerns it, who controls all its movements, and who alone has the right and power to send it into action. He has taken upon himself the responsibility of its efficiency and conduct, and it is very possible that should he take it into action he may command it in person.

In his position as chief of the army, the Kaiser is assisted by the military cabinet, composed of a number of high military authorities, whom the Kaiser elects as overseers of the various departments of the service, and whose duty it is to report to His Majesty in council all that takes place in the German army and in the armies of foreign nations.

Next to this is the war office which is under the charge of the minister of war. The latter is a soldier of long and varied experience, who also represents the army in the Reichstag, answering the questions asked by deputies concerning it, and negotiating in the Reichstag the yearly grants necessary for the maintenance of the army.

The war office is divided into a number of sub-offices, each under the control of its own military chief, who is subordinate to the war minister. From these offices instructions, money, provisions, and all other necessaries are dispatched to the units in the barracks or in the field. Thus the whole organization meets under one roof, which prevents any confusion or the possibility of one part working against another, and constitutes the war office the great controlling house without which the army would fall to pieces.

But the organizing power, the brain, the eyes, the ears, the very soul of the army, is the general staff. This is a colossal institution, composed of only the picked men of the whole army—those men who have distinguished themselves by their military genius, their knowledge of tactics, their capacity for organizing and inventing, or by other distinguished qualities calculated to increase the efficiency and usefulness of the army. They are all of them men with ideas, and of unquestionable ability, devoting themselves entirely to the work of perfecting the complicated machine of which they are parts. The general staff is also the intelligence department, and is responsible for all necessary information regarding the strength, movements, guns, arms and every conceivable particular concerning foreign armies, forts, defenses, and the like. According to this information, changes are made in the German army to cope with every emergency, and plans for attack or defense are worked out. Basing its conjectures upon the information in its possession, the general staff has considered every possible chance of an attack upon Germany from any quarter, and has shown how such attacks are to be repulsed, and how the enemy is to be driven back. Recognizing the possibility of an offensive campaign, it has worked out, on paper, campaigns in foreign countries. Locked away in its secret safes the general staff has its plans, prepared with the greatest mathematical exactness, for the conquest of nearly every nation.

It is when one comes to know something of the general staff that one realizes what the German army really is, and understands something of its magnitude. To discuss the possible success or failure of its plans and theories would be idle. The fact that these have been prepared, and are kept constantly up to date, is a proof of that spirit which courts success, and of the determination of the nation to be ready for each and every emergency. All these plans and theories are tested from time to time in the light of recent events. Struggles between combating powers are watched by the general staff with the closest attention, all the incidents marking their progress are impartially criticised, and the lessons learned from these are applied in practice, forming the groundwork for changes and improvements. Another equally important duty is to secure carefully prepared plans of all countries in which Germany may at any time be called upon to carry out military operations.

Probably the most serious work falling to the general staff is the arranging and preparing of secret plans for the mobilization of the army and reserves the moment war is declared. As a knowledge of these plans would be of incalculable service to a hostile army, and as there is always the possibility that some part at least of the secret may be betrayed to some interested foreign power, the plans have to be constantly changed and altered, which means that the work on them is never ceasing. With what smoothness these plans work, collecting the whole fighting army and transporting it to the scene of action, together with all necessary munition and provisions, was amply demonstrated during the Franco-German war of 1870-71. Then, as now, every general had his sealed orders and a time-table, which it was only necessary for him to follow in order to arrive at the scene of action at the time he was expected. So well did these arrangements work out that, though hundreds of units were involved in the various movements, Moltke could calculate with certainty to within a few minutes upon the arrival or departure of any one of these units.

To-day, with increased railway facilities, the system is even more perfect. Yet the railways have added to the complication of the task, making it more difficult to get a comprehensive view of the perplexing network of lines throughout the country; and the work of timing the arrival and departure of trains from all parts of the Empire, and of managing everything so that no block can possibly happen, drives many officers insane. This work in the time-table department is so dreaded that it is difficult to induce officers to take to it, in spite of the increased social advantages which such a position on the general staff offers them.

This is, as briefly as it may be told, the composition and machinery of the army which was established by Frederick William I., and developed by Frederick the Great into that powerful weapon which has helped to make the nation what it is to-day. Its history has been checkered, and does not always justify the pride with which Germans boast of its deeds prior to its achievements in the war against France, or even since then; yet no one can gainsay that as a fighting machine it is as nearly perfect as human means and genius can make it. It certainly is a wonderful institution, a marvel of ingenuity and organization, a monument to the patience and skill of those who are responsible for its existence.

The motto of the German army is "Ready," and that is the keynote of everything done in every department of it. A solid business-like spirit pervades everywhere, and nothing that brains, energy or money can suggest or do is spared, nor anything left undone which may help to keep it true to its motto and be always "ready."

Unfortunately it is an axiom that there seldom is a good that has not its attendant evil; and German militarism is no exception, as the Germans themselves are the first to admit. One of these evils is its increasing cost to the nation; but this must be looked upon as a necessary evil, since the army is the symbol of settled security to which the nation owes its existence, and endows it with that confidence so essential to industrial and commercial success.

Heavy as it is, the cost of maintaining the army is not the heaviest part of the military burden. It is as nothing compared to the enormous sacrifices which universal military service demands; and this hits hardest the middle or commercial classes, whose sons must give up to the army some of the best years of their life, which, needless to say, generally proves a severe handicap to them in the prosecution of their studies or the following of their commercial pursuits. The frequent claims which the army makes upon their time at varied periods cause a feeling of unrest and dissatisfaction. On this very practical point all the German's theoretical pride in the army vanishes. He complains that universal military service is a vicious, unrelenting institution, which makes no allowances or exceptions, which never takes into consideration whether or not it is ruining a young man's chances in life. It is so far-reaching that it hinders and upsets the ordinary course of business. Merchants and manufacturers look upon it as a bugbear. Almost the first question they ask an applicant for a vacancy is if he has finished his military service; and if he has not, they prefer not to employ him. They complain that they no sooner have taught a young man their business methods, and find him of use to them, than he must leave them for the army, and they cannot afford to let their business stand still until his return, so they have to fill his place as best they can; and when the young man leaves the service he is without a situation. No amount of argument can prove that it is a good thing to disturb the routine of a business, either for employer or employed. Therefore, however beneficial compulsory service may be for the nation, it damages the individual. And the hardships do not cease on expiry of the first term of military service, for when the reservist goes to exercise for eight weeks with his regiment either he and his family must suffer, or his master.

When a man settles down in business for himself his case is even worse, if possible, for it has happened that the army has ruined many who had to begin in a small way. An instance of this was reported in the newspapers quite recently, and it may be taken as typical of many, though fortunately they are not all attended with the tragic circumstances which brought this case before the public. A man invested all his capital in a business, to which he applied himself with diligence, and began to do very well in it, until he was called out to serve some weeks with the Reserve. Unfortunately for him, he had not the means to afford a substitute to keep his business going during his absence. On his return he shot himself, and the examination proved that his reason for doing so was because his business, which depended entirely upon his personal effort, was hopelessly ruined through his having to close it for so long a time.

Another objection to universal military service is that it is dangerous to health—not the actual service, but the dread of it. Nearly all enterprising young men desire to escape military service for no other reason than that they wish to enter at once upon their life-work. In the hope of unfitting themselves for passing the doctor's examination they tamper with their health, often causing such damage as to ruin it permanently.

It is because of universal military service that Germany has never been a successful colonizing power. The adventurous young men, those who might be getting about the world, and probably winning territory for the fatherland, are obliged to stay at home for the army. If they do go away, they must return within a certain time and at their own expense. This is seldom convenient or practical, and compels them to choose the alternative: either they must give up what prospects they have before them and become soldiers, or they must throw off their allegiance to Germany entirely, becoming citizens of the country in which they have settled.

The present condition of Germany's colony in Southwest Africa is a startling revelation of the failure of conscripts, as compared with volunteers, to keep law and order in a colony. In the disastrous campaign against the Hereros, Germany refused to employ men who lived in the country, who had their interests

* Chambers's Journal.

there, and who knew the ground; preferring conscripts from home, who went out feeling they were going to martyrdom. One way or another, they managed to drag out the punitive expedition for an unconscionably long period, and few of them returned with much glory to themselves.

Realizing some of the drawbacks of universal military service, the government has tried to minimize its hardships by introducing what is known as the Einjahrig Frei-williigedienst, or one-year service. The privilege of serving for only one year instead of two is granted to all who pass the middle classes of a high school. For this privilege they have to pay all the costs out of their own pocket. These include kit, uniforms, board and lodging, a man-servant, and the numerous expenses incidental to a soldier's life, which in the crack regiments may run up to a thousand pounds for the year, and which in the so-called cheap provincial regiments average two hundred and fifty pounds. From these one-year service men are recruited the officers of the Reserve, and as this title carries with it much influence, most young men are ambitious to obtain it. But as a very large percentage of those who possess the necessary certificate have not sufficient money to pay their expenses, they are obliged to launch into debt, and to place themselves and their parents under obligations, which burden hampers them in their future career. Hence many young men who have the one-year service qualification and not the necessary funds are obliged to serve as ordinary soldiers; for although the government has a fund for assisting such, the conditions under which it is granted are not particularly enticing.

Another objection to this favor shown to educated men is that one-year service men are not popular with the ranks, being considered the legitimate sport of all who can take advantage of them. Nor are they looked upon with much favor by drill instructors, except in those instances where there is a prospect of future gain. The drill instructor is generally more noted for his bullying and abusive proclivities than for his intelligence, and only too often uses the power confided in him to make the soldier's life unbearable. His idea of a soldier is that he is something like a wild animal, which must be trained to do a certain number of things in a certain way within a certain time. The authorities allow him considerable latitude as long as he produces the results required of him, though he has frequently to be court-martialed for the brutal and disgusting methods he adopts.

For a man of education and self-respect to submit himself to the rule of such a drill instructor is to feel degraded and insulted. Rather than undergo this treatment many young men leave the country, never again to return to it; for the pains and penalties awaiting them in the event of their return are more terrible than the method of the army they flee from. The mere fact of their running away proves them, in many cases, to be young men of spirit and pluck, such men as the country cannot easily afford to lose, who, were they permitted to remain at home, would turn out useful members of society. As it is, they look back upon the Fatherland with no particular pride, and their parents often curse the evil which robbed them of their sons; and when a son longs to return through illness in the family, or when other occasion requires his presence, he is kept away by fear of the authorities, who are waiting for him the minute he puts his foot upon German soil.

For this reason, it is to be feared that the army is killing patriotism in Germany, even in the army itself. The service is dreaded more and more as industrialism advances, and the only good thing that men have to say for it is that they have done with it. So strong is the feeling against it in the middle classes and the lower classes that were it not for universal military service very few men would be soldiers in Germany. Doubtless when the necessity arose volunteers in plenty would flock to the standard, but during peace-times the army is far from popular, and individual pride in it is more abstract than real or practical.

It may be possible that the conditions of life for which the army is responsible account for the sad fact that so many Germans when they go abroad deny their own country. It may also be for the same reason that they permit themselves so readily to become absorbed by other nations, making good citizens of other lands, to the abiding loss of their Fatherland. The greater freedom they enjoy abroad appeals to their imagination; they feel themselves more the masters of their fate, and they take advantage of every opportunity offered them by throwing off all their allegiance to the home-country and naturalizing in the new.

Many complain that the army is an institution which the introduction of commercialism has antiquated, an institution that has not kept pace with the forward march of events. Much dissatisfaction is found in the army itself. The men complain that they have far too much drill and too many parades; that they have to go through exercises from sunrise till sundown, until they are completely worn out. There is also much grumbling about the food. It is of a kind to which many of them have not been accustomed at home, and which, they say, is no more than sufficient to keep up their strength. The coarse black bread they can hardly eat, and the pay they receive is not sufficient to keep them in tobacco. Consequently they are dependent upon their parents and friends to send them hampers of food and money. Their great longing is for the time when they will be able to return to civilian life, and they tick off on their calendars the days as they pass, anxiously counting the time that remains between them and liberty.

Even the officers have their grievances. They feel in all things the power of the "one hand," as they express it; that the army is too much the Kaiser, being held in subjection to his absolute will. Every now and then he introduces changes in the officers' equipment or the style of their uniforms by way of experiment, the cost of which comes out of the pockets of the officers, who grumble about the expense. Officers are in no sense of the word free agents. Even their opinions are prescribed for them; and if they hold views on politics, government, and progress which are known to be at variance with those held in high quarters, they are compelled to run the gauntlet, and possibly to leave the army. They are forbidden to smoke in the three fashionable streets of Berlin; and if, when they are driving, they meet a royal equipage with the coachman holding his whip aloft, thereby denoting that some royal personage is behind him, the officers must stop their carriage, alight, and stand at the salute until the royal equipage has passed by. No officer can marry without the consent of his superiors, who inquire if his intended wife is a fit associate; and should the result of the inquiry prove favorable, a fixed sum of money must be invested in the regimental funds, upon the interest of which the officer and his wife may be able to keep house and entertain in a manner befitting their position in the army.

Doubtless the sorest point of all among the officers is the slowness of promotion. Because of this, many of them, who are poor to begin with, and who have not the good fortune to marry money, have to eke out their salaries by remittances from home until they are over forty years of age. Usually an officer without influence serves something like twenty years before he obtains a captaincy, and before he can attain to any of the more lucrative positions he has reached the age-limit, and is retired on a pension wholly insufficient to keep him in comfort. It is stoutly maintained, and with some show of truth, that all the good posts in the army go to favorites belonging to the nobility, who practically hold a monopoly of such positions.

Much has been said in praise of the German army as being a good training-ground for the rougher element of the population, instilling into it some notion of discipline and orderliness. This the army may do, but it is questionable if the good wrought in this way is in due proportion to the evil wrought in other ways—as, for instance, when a young man who has been carefully brought up at home enters the army and comes into contact with the evil influences of the questionable characters around him. Whether or not he submits to these is merely a question of temperament and character. The chances are that in the process of having his eyes opened he gets somewhat contaminated, and returns to his home a different man morally from what he was when he left it. In any case, it is not a particularly pleasant prospect for respectable parents to have the knowledge that their sons are likely to be boarded together with young men whose respectability is so questionable that the army contemplates reforming them.

Considering the large number of men serving with the colors there is comparatively little crime in the German army. The latest statistical report for the year 1907 gives the number of military and civil offences dealt with by the military authorities at ten thousand two hundred and fifty-three, and this proves a considerable decrease on the previous year. There are, however, a number of irregularities for which the army is either directly or indirectly responsible, but which are not included among the offences, and are therefore not published in statistics. The army is more concerned about drill than about morals. Its one and only aim is to lick the soldier into proper shape, so that he may fit exactly into his place in the machine. Its method of accomplishing this end is systematically to crush all individuality out of him, and to make him one of the crowd, moving in blind obedience to the word of command. Hence officers will tell you that in a whole regiment they cannot find more than twenty or thirty men in whom they can place any confidence; and it is on those few that they must rely for leading all the others, whom their officers characterize as being hopelessly stupid and entirely innocent of any common sense.

This is not a particularly favorable comment upon what is often lauded as being the great social and economic advantage of the army—the advancement of the education of young men whose schooling has been neglected. True, there are schools in which those soldiers who come to the army ignorant of orthography may learn to write their names legibly, but it is questionable if beyond this they learn anything of real practical value to them. Young men who have been brought up on farms naturally have their wits sharpened through contact with the new world into which the army introduces them and the new companions whom they meet. Yet experience goes to prove that this kind of education is not always good for them. It makes them dissatisfied with the country life they have hitherto led, and causes them to look upon it as being narrow and cramped, and in order to escape it they remain in the overpopulated towns, adding their quota to the unskilled labor markets. Thus the education received in the army has been largely responsible for the undoing of Germany as an agricultural nation, a result which the military authorities have tried in vain to avoid.

Realizing the seriousness of this, the Kaiser has now thrown all his influence into the movement which is endeavoring to stem the tide flowing townward. What he most wants is the healthy type of soldier who hitherto came from the agricultural districts, but who is fast disappearing. The various schemes favored for the accomplishment of this end are likely to cause some interesting developments in German legislation, especially when the land reform question comes to be finally dealt with.

So long as the army remains one of the greatest factors in the country for the spread of political propaganda, a small holdings scheme, or any other plan, can only meet with partial success. Political influence is working more mischief than the authorities can counteract, much as they try to check it. What gives them the gravest concern is that this political influence is mostly in favor of the spread of the Social Democratic agitation. The members of this party serving with the colors soon succeed in interesting their dissatisfied comrades in the movement, and introduce them to their societies. Those men who later return to the country districts take with them their new political ideas, influencing people in remote parts who have never before heard anything about the party, and this had a tangible effect at the polls at the last elections. It is a very important part of the Social Democratic organization and plan of campaign, and the party, in spite of its recent defeat, succeeded in adding over five hundred thousand votes in its favor in the course of a few years, and that in face of the strenuous efforts of the government to effect a reduction.

The seriousness of this influence is proved by the fact that the authorities do not trust men to serve in the regiments stationed in their native districts. For instance, conscripts from German Poland are made to serve in West Prussian regiments or are brought to Berlin, while those from Elsass and Lothringen are sent to the Polish province and to East Prussia. In this way towns are garrisoned by men who are entire strangers to the districts, so that in the event of a rising among the inhabitants there is little chance of any sympathy between the latter and the soldiers whose duty it would be to deal with them. In any case, the authorities admit that dividing the troops in this way gives them a feeling of greater security.

These are a few of the problems with which this great organization has to contend, and which are apparent to the casual observer. Yet it must not be inferred from them that there is any corruption in the army itself which would in any way affect its efficiency in the field. To be led into such a mistake would be fatal. It is so entirely under the power of the authorities that such a condition is altogether out of the question; nor, indeed, is there on the part of those serving in it any desire to see it otherwise than the powerful weapon of war that it is, probably the most powerful that has ever been invented.

Norway is a country of vast mineral wealth. The richest iron mines are situated in the northern part of the country, as well as in the Trondhjemske. It has been calculated that the mines at Sydvarager contain 100,000,000 tons, and that the yearly production will be 600,000 tons. Operations on these mines will probably commence next summer. The work at the Dunderlandsdalen mines has been stopped for some time, but it will be resumed in the near future, when the Swedish method of treating the ore will be employed, with the hope that the works will produce 1,000,000 tons a year. It is estimated that the mines in the Tromso district contain about 30,000,000 tons of ore. Machinery has lately been erected in these mines. The yield will be about 200,000 tons per annum. Several other mines in the north indicate abundance of iron ore.

THE STORY OF SILK.

FROM COCOON TO FABRIC.

BY JOHN L. COWAN.

To THE far East belongs the credit of the beginning of the world's great silk-manufacturing industries. For more than three thousand years China jealously guarded its practical monopoly of the precious fabric (a small quantity being produced in India and other parts of Asia) and great caravans laden with raw and woven silks journeyed from the cities of the Celestial Empire to Syria and other countries. The Persians became the intermediaries in this trade between China and Europe, supplying the Greeks and Romans until the middle of the sixth century A. D.

This traffic was interrupted by a war waged by the Emperor Justinian against Persia, and the silk-manufacturing industries of the Byzantine Empire were brought to the verge of ruin, when two Nestorian monks, journeying from China, brought relief with a quantity of concealed silkworm eggs. These eggs were delivered to Justinian, who for a time monopolized the silk industry of the Occident; but after his death, in 565 A. D., the production and manufacture of silk became widely disseminated. It is claimed that all the silk now produced in Europe is spun by caterpillars descended from those hatched from the eggs smuggled out of China by the two monks thirteen and a half centuries ago.

The silkworm is known to entomologists as the larva of the moth *Bombyx mori*. The eggs are small, resembling turnip seeds, about one hundred weighing one grain. They are hatched by artificial means, and the larvæ, or caterpillars, are reared in rooms where they may have an abundance of light and air, with little variation in temperature. They are voracious feeders, and are kept liberally supplied with freshly gathered leaves of the mulberry tree. They grow rapidly, and (as a rule) molt about the sixth, tenth, fifteenth, and twenty-third days after hatching. In from thirty-five to forty days, having increased in weight about ten thousand times, and grown to a length of about three inches, they climb upon twigs and small branches that have been supplied to them for that purpose, and begin spinning their cocoons. In this process the caterpillar ejects from convoluted glands along the sides of its body two lines of viscid, semi-fluid filamentous secretion, through the spinneret located just under its mouth. The two filaments coalesce into one as they harden. In twenty-four hours after beginning to spin, the worker is hidden from view, and in from three to five days the cocoon is complete; and the industrious caterpillar, having lost half its weight and shrunken to half its size, is metamorphosed into a chrysalis, housed in an oviform lodge from an inch to an inch and a half in length, and from half an inch to an inch in diameter.

Left to the processes of nature, in time the chrysalis will break the filaments of the cocoon, and come out a full-fledged but an unattractive moth, which thousands of years of domestication have practically deprived of the power of flight. When the moth lays from three hundred to four hundred eggs, its mission of reproduction is accomplished, and it then dies.

But in breaking the fibers to permit its emergence, the moth materially depreciates the value of the cocoon. So only enough to serve as seed are permitted to complete the life cycle, and all other cocoons are placed in steam heaters to kill the occupants.

The cocoon consists of an exterior portion of straggling filaments (by means of which it was anchored to the twigs or branches that supported it) and a closely cemented sheath, somewhat resembling parchment, around the body of the chrysalis. The threads of this sheath are so tightly glued together that they cannot be unwound until after it has been thoroughly soaked in water. The exterior portion is removed, being known as floss or waste, and is spun along with the material of broken or defective cocoons, by methods similar to those used in the case of cotton, linen and other fibrous materials. The filaments of the perfect cocoons are caught on a fine brush, four, five, or six of them passed through an eyelet to a reel, and wound upon this is a continuous thread from 800 to 1,000 yards in length. From these reels the silk is taken in skeins, constituting in this form the raw silk of commerce.

The world's supply of raw silk is derived from China, Japan, India, the Levant, Italy, France, Austria, and Spain, amounting to something like 55,000,000 pounds annually. This takes into account only the exports of Asiatic countries, as there is no way of approximating an estimate of what is woven and worn in China. China really produces more silk than any other country, but the vast amount consumed at home (certainly more than half of the production, and more than one-fourth of the world's supply) never reaches any center of international trade, and never figures in statistical tables. With this qualification, the following table (published by the Silk Association of America) indicates the relative importance of the various silk-producing countries.

Tussah silk is usually known as wild silk, being the product of an oak-feeding caterpillar of China and India.

The following table of imports of raw silk for the fiscal year ending June 30th, 1909, indicates from what source the silk manufacturers of the United States derive their supplies:

	Bales.	Pounds.	
Japan	91,552	12,317,520	$44,464,737
China	43,894	5,749,425	15,920,881
Europe	23,165	5,096,300	20,584,965
India	213	38,600	115,163
Total	158,824	23,201,845	$81,085,746

It is evident that by far the largest part of the American supply comes from China and Japan. This reaches the United States by way of the ports of the Pacific Coast, where it is placed on board a "Silk Special"—a train that has the right of way over all the others, and hurried through to New York. No train is the object of more care and solicitude on the part of trainmen, as each car is loaded with a product worth $125,000 or more, and the train may carry silk worth anywhere from $1,000,000 to $2,000,000.

BUILDING UP THE JACQUARD HARNESS, SHOWING THE DIFFERENT STAGES.

THE STORY OF SILK.

SILK ASSOCIATION OF AMERICA.

Raw Silk Production in the Silk Seasons 1904–1905 to 1909–1910 in Kilogrammes and Pounds, Including China Tussah Silk.

Crop of (in Kilogrammes)—	1909–10 Estimated Kg.	1908–9 Kg.	1907–8 Kg.	1906–7 Kg.	1905–6 Kg.	1904–5 Kg.
Europe	5,230,000	5,558,000	5,917,000	5,750,000	5,495,000	5,917,000
Viz.:						
France	650,000	653,000	662,000	605,000	632,000	625,000
Italy	4,100,000	4,490,000	4,820,000	4,745,000	4,440,000	4,900,000
Austria	400,000	340,000	360,000	344,000	345,000	315,000
Spain	80,000	75,000	75,000	56,000	78,000	77,000
Levant	2,900,000	2,700,000	2,931,000	2,515,000	2,435,000	2,186,000
Asia: Total quantity exported*	14,700,000	13,907,000	11,991,000	10,925,620	9,375,120	10,947,350
Viz.:						
China, Shanghai †	4,200,000	3,750,000	3,100,000	2,847,100	2,583,000	2,950,047
China, Canton	2,000,000	2,367,000	2,250,000	1,883,000	1,922,120	2,137,785
Japan, Yokohama	8,100,000	7,490,000	6,301,000	5,900,520	4,590,000	5,679,518
Bengals	400,000	300,000	340,000	295,000	280,000	180,000
Total, kilogrammes	22,830,000	22,165,000	20,839,000	19,190,620	17,305,120	19,050,350
Tussah, raw	1,900,000	1,800,000	902,520	1,235,760	1,231,560	1,175,820
Grand total, kilogrammes	24,730,000	23,965,000	21,741,520	20,426,380	18,536,680	20,226,170
Grand total, reduced to pounds	54,519,758	52,833,239	47,931,311	45,031,997	40,865,964	44,590,614

* The production of raw silk in China is an absolutely unknown quantity.

† Excludes Tussah silk.

The figures for Asiatic silks are the actual shipments from the various countries of production, viz.: China, Canton, Japan, etc.

The estimated supplies for 1909–1910 are the probable crops for the season, plus the stock on hand carried over from the previous season.

The domestic consumption of Japan is estimated to be approximately 40 per cent of her production. The remaining 60 per cent, which is exported, being, say, 6,301,000 kilogrammes in 1907–1908 season, the total production equals the export divided by 60 and multiplied by 100, which, therefore, amounts to 10,501,666 kilogrammes.

The domestic consumption of China is estimated to be 55 per cent of her production in average years. The remaining 45 per cent, which is exported, being 6,252,320 kilogrammes from Shanghai, Canton and Tussah in 1907–8 season, the total production equals the export divided by 45 and multiplied by 100, which, therefore, amounts to 13,894,488 kilogrammes.

All raw silks imported into the United States are taken to New York, which now ranks second only to Shanghai among the world's raw silk markets. Silk in its natural state has an unconquerable affinity for moisture, so that thirty per cent of the weight of a bale may consist of water, without anything in its appearance to indicate that it contains an abnormal proportion of that liquid. This is a consideration that the purchaser of a commodity worth from three to five dollars a pound cannot afford to disregard. For this reason the process known as "conditioning" is necessary preliminary to negotiations for a sale of the product.

Sample skeins are taken from different parts of every bale, and weighed with great exactness. These are placed in conditioning ovens, having a temperature of 284 deg. F., and desiccated until absolutely

FRONT VIEW OF BOX LOOM. HARNESS COMPOSED OF 18 SHAFTS WEAVING FOUR COLORS.

devoid of moisture. Then they are reweighed, and the difference indicates just how much moisture they contain. This gives a basis for the calculation of the weight of the silk in each bale. To this eleven per cent is added, as an allowance for the normal amount of moisture in raw silk. Other tests are made to determine the fineness of the threads, their elasticity, tenacity, and twisting qualities; and all data are then at hand necessary to enable buyers and sellers to settle on the important question of price.

The first step in the manufacture of silk is known as throwing. The skeins are inclosed in light cotton bags and soaked for several hours in warm soapy water. Then they are dried in a hydro-extractor and stretched upon "swifts," or skeleton reels, adjusted to hold the skeins tightly. Then the filaments are wound upon bobbins, and cleaned by being passed from one bobbin to another through the cleaner, which consists of two parallel plates so adjusted that there is just room for the thread to pass through. Single silk (from which pongees are woven) is not doubled or twisted, but is ready for the scourer and dyer just as it comes from the cleaning process. Tram silk is made by twisting two or more singles together, then doubling and twisting again. It is used for the woof thread in weaving. Organzine is made by the union of two or more single threads, twisted separately in the same direction, and then doubled and twisted in the opposite direction. It is used chiefly for warp threads. The thrown silk is then scoured to remove some of the natural gum, so that it will have greater luster and take the dyes better. Shaking, glossing, and lustering are processes for which special machinery have been devised. After developing the luster of the silk, it is ready for the dyer.

If properly handled, silk is the strongest and most durable of all textile materials; but the various processes of manufacture that remove much of the natural gum, cause it to lose so large an amount of its weight that unscrupulous dyers and manufacturers resort to "loading," dipping the thrown silk into a solution of bichloride of tin. Some are not content with restoring the original weight of the raw silk, but "load" it until its weight is multiplied three or four fold. This operation makes the skeins bring more money, but it destroys the durability of the filaments. Stretching the threads to their elastic limit, so that a given weight will weave a greater number of yards, and steaming to give the material an unnatural luster, are other processes that prove profitable to manufacturers, but costly to the consumers; and that cause many people to regard silk as an uncertain and treacherous fabric, with an inexplicable tendency to split, crack, and fall into holes, even though packed away in drawers or hanging up in closets. The use of cheap, inferior, and destructive dyes is another practice equally injurious, and perhaps still more common, so that the purchase of silks is often a good deal of a risk.

There are in the United States a few great establishments in which all processes of throwing, dyeing, and weaving are performed; but as a rule these are conducted as entirely separate industries.

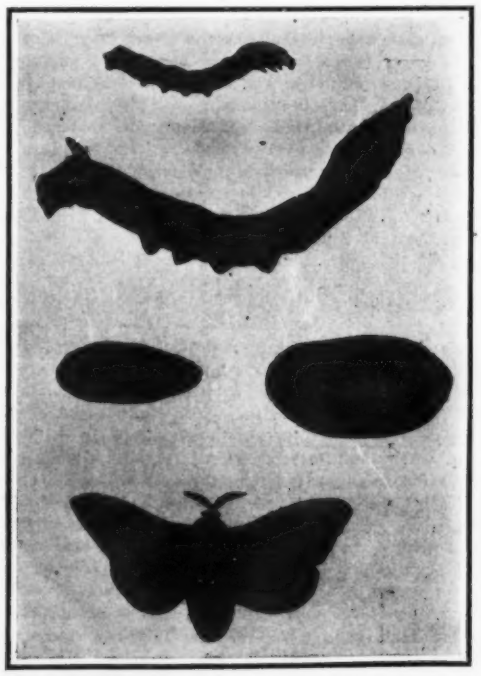
In any woven fabric there are two systems of threads—the warp or chain, running lengthwise of the cloth; and the woof, or filling, crossing the chain at right angles. The dyed silks reach the factories in the form of skeins. Skeins intended for the filling are placed upon swifts and wound upon spools, or bobbins, and thence upon smaller spools, called quills, that fit into the shuttles. Threads for the warp or chain are wound from the skeins upon bobbins, and these are placed upon an upright frame. Then the threads are passed through the lease reed, for the purpose of crossing them as they are placed on the warping mill, so that each thread will always be kept in its proper place. From the lease reed the threads pass through the front reed, and from this over the warping mill, a huge creel eight yards in circumference fitted with a measuring apparatus so that the warp can be cut off at any length desired. The front reed adjusts the width, controlling the number of threads per inch, varying from 100 in light summer silks to 448 in heavy goods. The warp is placed upon the creel in sections, and then all wound off together upon the beam placed in the rear. When complete, this beam is removed and placed in position at the rear of the loom. If there are different weaves in the same warp (as, for example, satin and taffeta) each must be p'aced upon a different beam, as one weave will take up more than the other, and it is essential that all threads be held taut.

Any description of mechanical operations is necessarily vague and difficult of comprehension, unless the printed or spoken word can be supplemented by the eye as an aid to the understanding. Therefore no detailed description of the operation of a modern loom will be attempted, but mention will be made of some of its essential features. It consists of a strong iron frame, at the back of which is the horizontal beam or roller from which the warp unwinds, while at the

REAR OF WARPING MACHINE, SHOWING BEAMING ATTACHMENT.

front is the roller on which the web is wound as woven. Between the two is the harness. This is a series of frames with eyelets, one for every thread or set of threads of the warp. In plain weaving the harness frames are in two sets, of three frames each, one set of which is up while the other is down. The number can be increased to several frames, each acting independently of all the others, for complicated patterns; and in the Jacquard loom the harness becomes a set of threads, instead of a frame, so that every thread of the warp can be raised or lowered separately. Between the harness and the take-up roller is the "lay," in which is the reed and a smooth projecting under portion along which the shuttles run. The warp threads, crossed as described in the lease reed preliminary to going on the warping mill, are held in position by the lease rods, then pass through the eyelets of the harness, and next through the reed. As the harness lifts one set of threads, the shuttle flies across the warp through the opening made by such lifting, and the batten (constituted by the reed and lay frame) beats the thread close in to its pre-

JACQUARD LOOM WEAVING FIGURED GOODS. THE HARNESS HAS 5,320 THREADS.



Silkworm fifteen days old. Silkworm thirty-five days old. Chrysalis. Cocoon. Moth.

BOMBYX MORI.

HAND-PAINTED DESIGN FROM WHICH PATTERN CARDS ARE CUT FOR JACQUARD LOOM.

THE STORY OF SILK.

decessor. The next motion of the harness lifts another set of threads, and the shuttle flies back through the opening, adding another thread. It is a process slow of description, but so rapid in performance that the eye can hardly follow the motion of the shuttles back and forth.

For weaving figured patterns, the Jacquard loom is used, or any loom fitted with the Jacquard attachment, named from its inventor, an ingenious Frenchman, Joseph Maria Jacquard. The pattern is regulated by an endless chain of heavy pasteboard cards, which pass over a square prism called the "cylinder." The cylinder is perforated with rows of holes to correspond with horizontal "needles" that control the warp threads. The pattern cards are so perforated that for all warp threads that are to be raised above the filling in the woven fabric, holes are cut for the needles, allowing them to pass through, and thus raising the threads. Where a hole is not cut through the pattern card, the unperforated cardboard stops the needle, and the warp threads are not raised.

The making of these pattern cards is of itself an important subdivision of the silk industry. The designs are hand-painted by skilled artists and designers on papers so ruled that there is a square for every crossing of the threads of the warp and woof. Then every square that is painted in (indicating a raised thread in the fabric) must be punched out in the cardboard, to permit the passing of the needle controlling the corresponding warp thread, so that the design may be carried out.

Of course as many colors as desired can be introduced into the warp, and by the use of a tier of shuttles, each carrying a different color, a considerable variety can be woven into the filling.

The woven fabric is next placed on a frame, and every square inch carefully examined, for the removal of dirt, knots, stains, and other imperfections. Finally it is taken to the finishing department, where the treatment depends somewhat upon the preferences or the inventiveness of the management of the establishment. In some cases the goods are singed, for the removal of any rough nap. The fabric is then sprinkled and sponged with a preparation of wax and gelatine (the exact nature and composition of which in many factories is a carefully guarded trade secret). The final gloss is imparted by calendering, in which the fabric is run between a series of superimposed steel rolls, ironing it out smoothly and giving the characteristic glossy finish.

From this brief sketch of the long and devious journey of a silk thread from the spinneret of the caterpillar to a condition fitting it for the adornment of a butterfly of fashion, the reason is plain why silk is the most costly of textiles. In every stage of every process of nature, art and machinery, from the feeding of the silkworms to the finishing touches of a fashionable dressmaker, silk is prodigal of labor, requiring skilled hands or watchful eyes to assist or supervise every operation. It is said that more time is required for the fashioning of a silk dress from the raw materials of the mulberry leaves than is necessary for the building of a locomotive from the ores as they exist in nature; and probably the co-operative labors of a greater number of persons contribute to the construction of the ballroom gown than to the construction of a mogul freight engine designed for the steepest of mountain grades. The only wonder, then, is that silk is not so costly as to place it beyond the reach of all but the very wealthy. That its price is so reasonable as to place it within the means even of the girls that watch the flying shuttles in the silk mills, is due to the fact that the silkworms are fed and cared for, and the filaments reeled from the cocoons, by the cheapest labor in the world—by the labor of the women and children of the Orient, the Levant, and the south of Europe; and to the additional fact that the various processes of manufacture are performed by the most perfect machinery that human ingenuity has ever devised.

Numerous and persistent attempts, extending over a period of a century and three-quarters, have been made to introduce sericulture into the United States as a paying industry; but these were foredoomed to failure by the evident impossibility of competing with the cheap labor of the older silk-producing countries. Government support of sericulture has been withdrawn, by the discontinuance of appropriations for the purchase of cocoons produced in America; and, with the failure of a rather ambitious enterprise in Georgia, all experiments of this kind appear to have been given up, excepting in San Diego, Cal., where some enthusiasts still hope for success. As a matter of fact, it is difficult to understand why anyone should greatly desire the permanent establishment of sericulture in America, knowing that it would be possible only by the employment of child labor at pitifully inadequate wages.

If the United States has failed in the production of raw silk, it has achieved a notable success in all branches of silk manufacture, excepting in the weaving of certain fabrics in which hand labor is largely necessary. This success is mainly due to American ingenuity in bringing silk throwing and weaving machinery to its greatest perfection. Mechanical power is applied to silk manufacture to a much greater extent in this country than in any other part of the world.

The beginning of silk manufacture in America dates from 1810, when the first silk mill on the western hemisphere was set up at Mansfield, Conn. In 1815, a silk trimming factory was established in Philadelphia; a ribbon factory in Baltimore, in 1829; a dress trimming factory in Boston, in 1834; and sewing silk factories were operated in Florence and Dedham, Mass., in 1835. In 1838 the first power loom was introduced into America, and small manufacturing plants were multiplied until by 1860 New York had 44 little establishments, Pennsylvania 35, Connecticut 22, Massachusetts 20, and New Jersey 9, employing a total of 5,352 persons. Yet the relatively small importance of these is shown by the fact that in 1860 the United States manufactured only 13 per cent of the silk goods consumed in the country.

In 1860, by the operation of the Cobden treaties, England admitted silks of foreign manufacture free of duty, and many English throwsters and weavers were forced out of their own markets. A number of these came to America, bringing with them their machinery and workmen. They settled in Paterson, N. J., making that city pre-eminent as the silk-manufacturing center of America. This pre-eminence Paterson still retains, although labor troubles in the 80's led to a scattering of the industry, many manufacturers locating in Pennsylvania and other States. It is doubtless true that the best interests of silk manufacturers, and of the country at large, will be served by scattering silk mills as widely as possible, rather than by concentrating in old industrial districts. The wage rate is low, so that the industry is suited rather to country districts than to great cities, where rents and the cost of living are disproportioned to the earning power of silk-mill operatives.

From 1860 the silk industry enjoyed steady growth, but that this for a time was slow is shown by the fact that in 1870 only 23 per cent of the silk goods consumed in America were of domestic manufacture. By 1880, the percentage was 38; in 1890, 55; and in 1898, 85. In 1868 the importations of raw silk were only 512,449 pounds. The next year they amounted to 726,695 pounds; in 1879 to 1,893,311 pounds; in 1889 to 5,329,646 pounds; in 1899 to 9,691,145 pounds; and in 1909 to the astonishing total of 23,333,750 pounds.

These figures tell an inspiring story of industrial achievement. Last year's importations of raw silk amounted to two-fifths of the world's total production. American silk mills represent an investment of more than $100,000,000 of capital, and give direct employment to more than 75,000 persons. The benefits to capital and labor as represented by manufacturers of machinery and dyestuffs, transportation interests, jobbers, retail dealers, dressmakers, milliners, and scores of cognate interests, cannot in any way be estimated.

Strange, is it not, that human intelligence and ingenuity have been able to develop the secretion of an ugly, crawling caterpillar into an article of such vast importance to international trade, to the worlds of finance, industry, transportation, and merchandizing, and to devotees of fashion and all admirers of the beautiful?

A TEST FOR INTELLIGENCE.

By PROF. R. S. WOODWORTH.

A good test for intelligence would be much appreciated by the comparative psychologist, since, in spite of equal standing in such rudimentary matters as the senses and bodily movement, attention and the simpler sorts of judgment, it might still be that great differences in mental efficiency existed between different groups of men. Probably no single test could do justice to so complex a trait as intelligence. Two important features of intelligent action are quickness in seizing the key to a novel situation, and firmness in limiting activity to the right direction, and suppressing acts which are obviously useless for the purpose in hand. A simple test which calls for these qualities is the so-called "form test." There are a number of blocks of different shapes, and a board with holes to match the blocks. The blocks and board are placed before a person, and he is told to put the blocks in the holes in the shortest possible time. The key to the situation is here the matching of blocks and holes by their shape; and the part of intelligence is to hold firmly to this obvious necessity, wasting no time in trying to force a round block into a square hole. The demand on intelligence certainly seems slight enough; and the test would probably not differentiate between a Newton and you or me; but it does suffice to catch the feeble-minded, the young child, or the chimpanzee, as any of these is likely to fail altogether, or at least to waste much time in random moves and vain efforts. This test was tried on representatives of several races, and considerable differences appeared. As between whites, Indians, Eskimos, Ainus, Filipinos, and Singhalese, the average differences were small, and much overlapping occurred. As between these groups, however, and the Igorot and Negrito from the Philippines and a few reputed Pygmies from the Congo, the average differences were great, and the overlapping was small. Another rather similar test for intelligence, which was tried on some of these groups, gave them the same relative rank. The results of the test agreed closely with the general impression left on the minds of the experimenters by considerable association with the people tested. And, finally, the relative size of the cranium, as indicated, roughly, by the product of its three external dimensions, agreed closely in these groups with their appearance of intelligence, and with their standing in the form test. If the results could be taken at their face value, they would indicate differences of intelligence between races, giving such groups as the Pygmy and Negrito a low station as compared with most of mankind. The fairness of the test is not, however, beyond question; it may have been of a more unfamiliar sort to these wild hunting folk than to more settled groups. This crumb is, at any rate, about all the testing psychologist has yet to offer on the question of racial differences in intelligence.—Abstracted from a paper read before the American Association for the Advancement of Science.

METHOD OF MANUFACTURING SULPHURIC ACID.

EXPERIMENTS have been made in Europe upon a new method of manufacturing sulphuric acid. While the usual process of roasting pyrites and similar ores is a very economical one, there are countries which do not possess such minerals in abundance, and therefore other methods are desired. For some time past attention has been given to the use of limestone for this purpose. A series of tests was made lately by H. Trey, and these consisted in the treatment of gypsum and alabaster of very pure variety which came from the basin of the Duna, Russia. Here are very abundant supplies of these minerals. They are treated by means of a very pure silica which is chemically prepared, and these ingredients are mixed in the theoretical proportions and are heated to redness in a platinum crucible so as to produce a double decomposition. The silica displaces the sulphuric acid, which is given off in the state of vapor. Taking the loss of weight, we estimate the sulphuric acid, which is about what theory would give. Such process takes from 30 to 40 minutes heating. The time of heat is lessened if we use silicious sand in place of pure silica. A test was made using crude gypsum and sea sand, and here the time of heat was reduced to 6 minutes. The acceleration is due to the catalytic action of iron compounds, which the materials contain in very small quantities, but there is no benefit in adding iron oxide (0.5 per cent) to the natural pure products, as the time is scarcely lessened. As the operation is made at a very high heat, the sulphuric acid is decomposed as soon as it is given off into water, sulphurous anhydride and oxygen, but these two gases can be combined by the usual processes so as finally to produce sulphuric acid. The sulphuric acid made by the new method has the advantage of being purer than what is given by the usual pyrites process, and does not contain arsenic, etc. The residue of the new process is silicate of calcium, which can be used in glass manufacture.

At Pola, at the head of the Adriatic, the largest wireless telegraph station on the European continent has recently been fully completed. It possesses a tower 300 feet high, built on a foundation of glass, from which antennæ spread over a ground surface of about eight acres. The station house is in two stories, the upper serving as a dwelling place, the lower as a working place. The high-tension room is isolated by thick walls and doors and windows of treble thickness. During the completion of the installation the station has been constantly tested over comparatively short distances, and has acted faultlessly. Full communication has been established with Berlin with a specially erected temporary station at Vienna and later with the city itself, and with Cattaro. Thus distances of 500 miles have been covered even before the arrangements were complete, and that with perfect success. Wireless messages were sent to the Kaiser on his yacht during his stay in Corfu, and during his voyage thence to Malta, whereby he was kept in regular communication with his ministers in Berlin. The scope of the station will be largely extended during 1910 and 1911.

WATER-VAPOR ON MARS.*

REPLY TO CAMPBELL'S CRITICISM.

BY F. W. VERY.

IN Lick Observatory Bulletin, No. 169, Prof. Campbell, in the course of comments on Dr. Slipher's and my results which show the presence of water vapor on Mars, says: "Very's results make the 'intensification' of *a* in the Martian spectrum more than twice as great at one time as at another. His greatest intensification is with spectrogram No. 3,062, for which Slipher says the *a* band is 'strong in both' Mars and moon; whereas only average intensification was obtained from spectrogram No. 3,050, on which 'the *a* band is all but invisible in both lunar images, but conspicuous in Mars'; a result apparently difficult to explain" (p. 161). The apparent discrepancy is not at all difficult to explain. It arises from the mode of reduction. By referring to Lowell Observatory Bulletin, No. 36, it will be seen that the apparent intensities of the telluric, or of the combined telluric and Martian, bands on each plate and in each spectrum have been reduced to the standard of their respective *Ha* lines, on the supposition that the latter are solar and therefore constitute one fundamental comparison object which is not subject to change through the variations of our shifting atmosphere, and which also enables us to eliminate any error depending on variation in the appearance of the spectral lines, due to changes of focus in the spectrograph, which are liable to occur in these long exposures owing to changes of temperature.

The method does not eradicate all possible variations capable of affecting the result, for there remain certain exposure and development factors on which Prof. Campbell frequently comments in describing his own plates, and to which I have alluded in describing the Lowell Observatory plates in Lowell Observatory Bulletin, No. 41, p. 223. Lowell Observatory Plate Rm. 3,062 is a little over-developed. The intensification of the *a* band would be normal without any reduction to *C* standard. In this case the reduction to *C* does not improve the result, but gives a ratio which is larger than the other ratios, and with a residual nearly twice as great as any of the others. Nevertheless, since the reduction to *C* appears to be justified, and, indeed, demanded by the necessities of the case, I cannot throw out a single aberrant measure for no better reason than that it is aberrant.

Prof. Campbell goes on to say: "It would seem either that Very's methods lead to erroneous quantitative conclusions, or that the quantity of water vapor over the whole equatorial region of Mars varied several fold between the dates of observation. Is the latter condition probable?" To this question the obvious reply is that a world-wide variation of aqueous vapor in the course of a few days is next to impossible; but no such interpretation of my measurement is necessary, since the discrepancies are no greater than those attributable to photographic factors. Must I then accept the other horn of the dilemma which Mr. Campbell presents, namely, that "Very's methods lead to erroneous quantitative conclusions?" It seems to me that such a characterization of my work is unjust and unjustified. The measured intensification of little *a* in Mars, given in my paper in conventional units from the mean readings for the five plates, was nine times as great as the probable error of the mean. No greater accuracy has been claimed for the result than that which is given by the probable error, and I have only used two significant figures in stating the final value.

Although the photometric measurements are difficult, the photometric methods are sufficiently trustworthy for the present purpose, and the final limit of accuracy resides in the uncertainties of the photographic process. The only way in which we can get rid of errors due to the circumstances of exposure or of development is by confining the investigation to those spectrograms which are not seriously affected by photographic disturbance; and here, by Campbell's own confession, the Lowell Observatory spectrograms must be given preëminence. He says (p. 162, *loc. cit.*): "In this connection, inasmuch as Very's measures refer to *Ha* (in the region of maximum sensitiveness on my spectrograms) and to *a* (in the region of very little sensitiveness), I note with unusual interest Mr. Slipher's success in giving the *a* region good density without over-exposing *Ha* and *B*. He makes no mention of having used an occulting screen, absorbent screen, or other reducer for the region to the violet of *a*, and one must conclude that he depended upon his chemical formulæ to achieve this result. The Mount Whitney spectrograms have intensity curves such that when *a* is fully exposed, *Ha* is essentially lost in over-exposure." In other words, it appears that Dr. Slipher has succeeded where Campbell has failed. It will be understood that I have not seen the Lick spectrograms.

In a letter to me, dated January 22nd, 1909, Mr. Slipher says: "The Mars and moon spectrograms were made for the lower end of the spectra, and no regard was given to having the actinic part, but, on the other hand, no screen was used to reduce the action of that part." This disposes of the doubt implied in the last quotation from the Lick Bulletin.

The last criticism which Prof. Campbell makes upon the method of measurement which I have employed is contained in the following paragraph: "Again, and of special interest in connection with Very's measures, it has long been known that the color curves of Mars and the moon are different; the spectrum of the planet is relatively rich in red. When the lunar and Martian spectrograms are equally dense at *Ha*, their *D* regions are unequally dense, with the lunar one plainly the stronger. With the *a* regions equalized in density, the *Ha* region is for the same reason a little stronger in the moon than in Mars. Are the ratios of the apparent intensities of *Ha* and *a* in the two spectra not affected by these conditions?" (P. 162.) On this point I answer that the variation in question does make a difference in the result, but only a very slight difference, and one which is negligible where the variation is no greater than in the present case. I have satisfied myself as to this by making measures under conditions far more unfavorable than those in the poorest of the present plates.*

Passing to the criticism made upon the interpretation of these measures, Prof. Campbell asks: "What assurance have we that the air columns through which Mr. Slipher observed Mars immediately after dark and the moon from two to eight hours later were carrying equal quantities of aqueous vapor? He appears to have taken no psychrometer observations at the observatory, but to have depended upon those made at the Weather Bureau Station, a kilometer distant and 105 meters lower, at 5:33 P. M." My answer to this is that measures of atmospheric transmission, made at a time when there were no marked storm movements at the given place, are but little affected by such slight changes as those indicated by the variation of the psychrometer reading at the earth's surface. It is the distribution of moistures through the entire air column that we should like to know, and this is hardly affected by such surface changes as occur in an arid region. The diminution of aqueous vapor so frequently noted at night in arid and elevated situations is presumably due partly to diffusion of moisture into the upper air at a time of day when there is little replenishment by superficial evaporation, and in part to an excessive depletion of moisture in a shallow surface layer of air through deposition of dew, although the latter cannot have been an efficient cause with the low relative humidity found by the Lick observers. The total quantity of water vapor in the entire column is not much changed by redistribution through diffusion, and any great accuracy in the determination of surface humidity would be labor wasted for the present purpose. A mean diurnal, or possibly a mean monthly, humidity may be quite accurate enough. The great dryness of the region about Flagstaff, and the infrequency of storms, consequently the moderation of fluctuations in the absolute humidity at this favorable site, must be considered in approaching this question. Variations in the relative humidity, such as are found in a limited layer of air in which cloudy condensation is either imminent or incipient, will have small influence upon the little *a* group, because it lies outside the limits of the diffuse band of absorption produced in a saturated atmosphere. In the daytime, it is true, a tall column of ascending moist air, tending to the production of a cumulus cloud, and intervening between our instruments and the sun, may produce a notable increase in aqueous telluric absorption; but the slight variation in condensation in the comparatively shallow layers of the night clouds need not be further considered in this connection. If we were dealing with the broad aqueous bands in the extreme infra-red spectrum, the problem would be different, for in these regions of the spectrum I have found wide variations from the passage of quite invisible masses of aqueous vapor; but it would take exceedingly refined observations to detect such changes in the *a* group. For these reasons we may dismiss Prof. Campbell's suggestion that "Very's numerical results refer chiefly to the relative absorptions of the aqueous vapor in our own atmosphere when Mars was observed at dark and when the moon was observed from two to eight hours (average four and one-half hours) later."

* Lowell Observatory Bulletin No. 43.

* By altering the illumination, the spectral background at either *a* or *C* was made of the same intensity as that of the comparison spectrum. The omission of this preliminary equalization increases the probable error, even though the direction of relative intensification of the lines remains unchanged.

CONCRETE IN PALESTINE.

DEPUTY-CONSUL John D. Whiting furnishes, in answer to an inquiry, the following report covering concrete in Palestine and its application in an uncommon way in a German sanatorium in Jerusalem:

Concrete, introduced into Palestine about twenty years ago, was first used only for making floor tiles. The materials used were sand and shells from Jaffa and cement from Germany. At first these tiles were made in wooden molds and pressed by wooden mauls, and without patterns, in either black or white. Some years ago a leading German merchant imported a European machine, and produces in his factory in Jaffa different sizes, colors, and designs of tiles, also concrete sewer and water pipes and railings, cornices, steps, and building blocks.

In Jerusalem the opportunity for selling floor tiles, p[illegible] steps, and perhaps cornices is quite large, especially the first mentioned. Little, if any, opening can be expected for using concrete building blocks, as stone is plentiful, and labor for quarrying and dressing it is cheap, while cement and sand are extremely high, since it costs $4 a ton to bring them from Jaffa by rail, although the distance is only about 53 miles.

In Jaffa the conditions are reversed. Little stone is found in the vicinity, and much of modern Jaffa has been built from sandstone brought from the ruins of Cæsarea and other old towns. This source of supply is now exhausted, and as stone quarries are scarce and the material inferior, concrete building blocks are growing in use. An inexhaustible supply of sand and shells is right at hand.

These blocks are now used in building corners of houses and for sides, sills, and arches of windows and doors, the spaces between being filled with sandstone, sometimes plastered over. The houses are sometimes finished off with a concrete cornice; often an entire balcony is thus made, the top, brackets, slabs, and railing being molded separately and cemented into the building. Concrete steps are also quite often used, and generally the floors are paved with concrete tiles.

Reinforced concrete has just appeared, calling forth much interest and curiosity from natives, especially masons. When the German Emperor and Empress visited Jerusalem in 1898 a carriage road from the northern suburbs up and along the ridge of Mount Scopus to the summit of the Mount of Olives was built for them by the Turkish government. From the top of Mount Scopus there is an extensive view. Jerusalem lies near by, below to the west, and to the east the Dead Sea appears only a few miles off, while it is over 20 miles, and beyond it and the Jordan valley extends the range of Moab.

It was this sight that impressed the Empress, and on her return to Germany a large sum was collected for building a sanatorium at this place, which is to be ready for use this spring. The cost is about $386,000, and it will be known as the Kaiserin Augusta Victoria Stiftung. It will be open to the German public. In this building concrete has been used in a different manner from that in general use.

The use of oil fuel is rapidly extending, and the time may be near when it will have an appreciable effect upon the demand for coal. In the United States a bill has been introduced into the Senate which provides for the creation of a reserve oil-fuel supply for naval purposes. It also authorizes the Secretary of the Navy to acquire suitable land adjacent to the oil fields of Oklahoma for the erection of tanks for the reserve oil supply, to establish buying agencies, and obtain all information necessary with regard to the cost per barrel of the oil required, and the cost per mile of pipes laid. The Secretary is authorized to purchase as fast as the market conditions will justify, 25,000,000 barrels of oil for the reserve supply of the United States navy. The British Admiralty has also given a big order for oil to be used in the navy amounting to 225,000 tons.

MICROPHOTOGRAPHY SIMPLIFIED.*

A CHEAP MICRO-CAMERA AND WHAT IT CAN DO.

BY BERNARD THOMAS, M.B., C.M.

MANY readers of Knowledge, who are students of the microscope, would no doubt be glad to have permanent records of what they see, and for this purpose I wish to describe a camera which anyone can make at a nominal cost out of simple material. What is wanted is a cardboard box about 4 inches square, a pill box or round match box with the ends knocked out, that will surround the top of the eyepiece of a microscope, an empty quarter-plate box, some strong wire, cardboard, black cloth or black paper, and plenty of paste. The camera, if it can be so called, is a dark box, the eyepiece of the microscope acting as a lens. A round hole is cut at the bottom of the open box, and on the inside of it is fastened the rim of the pill or match box. Level with the top of this and with a bend like this ⌒ in the middle, a piece of stiff wire is passed through the box, the wire outside being fashioned into a handle. Over the bend in the center of the wire a piece of stiff card is fastened. This drops over the eyepiece forming a lid, or it can be moved away and will drop back against the side of the box. To the open end of the box is pasted an open quarter-plate box the bottom of which has been cut out to form a rim to admit the image. Now it is all ready and only wants two or three thicknesses of black cloth or black paper pasted on it, care being taken that it is sufficiently light proof.

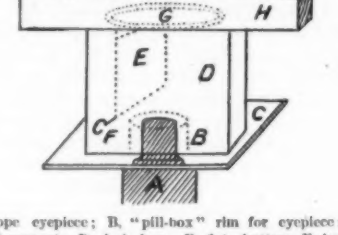
To take a photograph the camera is placed on the eyepiece of the microscope, which must be upright. A piece of ground glass placed on the plate box makes an excellent focusing screen. When, with careful adjustment, the image seems to be clearly defined, the box is removed from the microscope to the dark room, the plate introduced, and the shutter and lid closed. A piece of cardboard covered with black cloth the size of a quarter-plate and placed over it is an extra precaution. The camera is again fitted on the microscope, the photograph exposed, and then the remaining development done in the dark room. Certain points are worthy of note. First, when viewing with the ground glass the light may be screened by a cloth-covered funnel. Next, it is important to see that the adjustment of the microscope is sufficiently firm and not liable to be altered by the weight of the camera.

Lastly, the camera must be steady, and to this end remove the eyepiece and have a piece of stiff cardboard with a round hole in the middle which fits the microscope end of the eyepiece, and so, placing it in the tube, you have a platform on which the camera can rest. The diagram will, perhaps, explain better than any written description.

I have taken several photographs with this little camera, and the few presently to be described will give an idea what can be done. I showed this little camera and some photographs to the Chief Health Officer of Tasmania (Dr. Elkington), who is much interested in microscopic work. He was so pleased with it that he made one for himself. I believe he told his ministerial chief that he had made an addition to his department and installed a micro-camera for his work. He hoped the government would sanction the expense. The Minister was agreeably surprised when he found the item to be just 4½d.

With regard to the photographs.

Fig. 1 will no doubt be identified as a transverse



A. Microscope eyepiece; B, "pill-box" rim for eyepiece; C, thick cardboard support; D, dark box; E, flat shutter; F, handle for shutter; G, hole through plate carrier; H, plate carrier; H', lid.

section of the rhizome of the common bracken (*Pteris*). A fibrovascular bundle is well seen among the parenchymatous cells. Taken with a 1-inch objective exposure (in daylight) a few seconds.

Fig. 2.—Leaf of the bog-moss (*Sphagnum*). Here the interesting arrangement of the large transparent hooped cells surrounded by the smaller and narrower chlorophyll-containing cells is well seen. At the lower part of the photograph one of these "hooped" cells is seen with a hole in it. This is taken with a dry 1/10-inch; the exposure, consequently, is much longer, about a minute and a half.

Fig. 3.—Leaf of a common moss (*Funaræa hygrometrica*). The cells are lined with chlorophyll corpuscles. This also is taken with 1/10-inch objective.

Fig. 4.—Taken under the same conditions will be

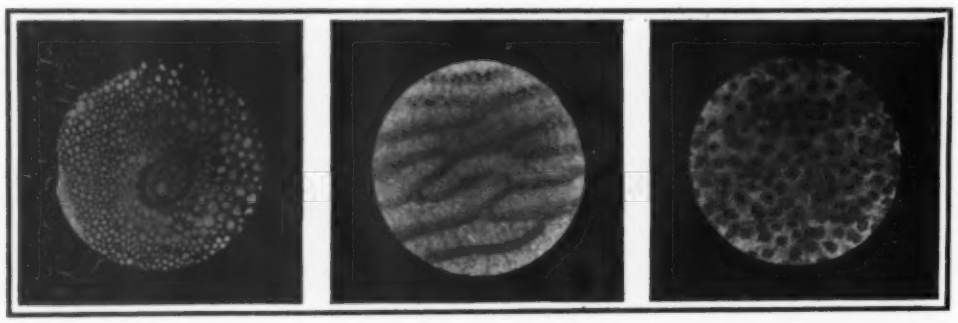


Fig. 1.—Transverse section of Rhizome of Pteris.

Fig. 2.—Leaf of Sphagnum.

Fig. 3.—Leaf of Funara Hygrometrica

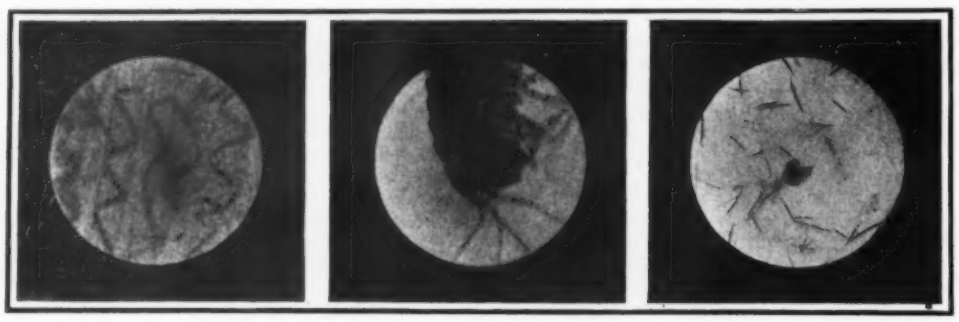


Fig. 4.—Filaments of Spirogyra.

Fig. 5.—Gammarus.

Fig. 6.—Hydatina senta feeding on Desmids (Closteria).

MICROPHOTOGRAPHY SIMPLIFIED.

easily identified as Spirogyra with the lovely green spiral bands.

Fig. 5.—The head and forepart of Gammarus, the fresh-water shrimp. One-inch objective and exposure about ten seconds.

Fig. 6.—Although, owing to unavoidable causes not quite clear, is of interest, because it shows a rotifer (*Hydatina senta*) in the act of enjoying a good meal of Closteria, one of which can clearly be seen in its jaws. Of course, its somewhat indistinct outline is due to movement.

Several other micro-photographs might be shown, but I have already encroached too much on the space of your interesting paper. I would like to add that all the photographs were taken on special rapid quarter-plates (Imperial) and developed with M.Q. tabloids.

* Knowledge and Scientific News.

COST OF POWER FOR VARIOUS PURPOSES.

IN a paper entitled "Cost of Power for Various Industries Under Ordinary Conditions," which was presented before the Boston Society of Civil Engineers, by Messrs. Charles T. Main and F. M. Gunby, the following general summary was given of the cost of electrical power for various purposes and under varying conditions. The prices quoted are approximately those found in the vicinity of Boston.

Power in small amounts and with a varying demand, can be purchased for from about 10 cents per kilowatt hour, in five kilowatt lots, down to about 6 cents a kilowatt for 100 kilowatt lots, where the power is used for about 50 hours a month.

The rate for a permanent or steady power of 100 kilowatts for 300 hours a month would be about $2.68 per kilowatt hour, and for 500 hours a month about $1.84 per kilowatt hour. The two conditions mentioned are only used as illustrations to show normal cases as in a city like Boston.

Assuming a plant of 2,000 kilowatts capacity, the approximate costs and prices for power are given in the following table:

Kind of Plant and General Use.	Hours per Year.	Cost per Year. K. W.	Cost per Year. E. H. P.	Cost per Year. I. H. P.	Cost per K. W. Hour.
Textile (engine).....	3,000	$32.00	$23.80	$20.80	1.065c.
Textile (turbine)... ...	3,000	29.00	21.60	....	0.965c.
Paper mill (engine)...	7,200	57.00	42.50	37.00	0.792c.
Paper mill (turbine).....	7,200	52.00	38.80	.....	0.734c.

The above figures are for cases where no waste products are used for manufacturing.

For electric lighting or railway work with a load factor of 30 per cent the cost would be about $1.55 per kilowatt hour, or $40 per kilowatt year. This is $29.80 per engine horse power year or an equivalent of $26.00 per indicated horse-power year.

For paper mill work, 24 hours a day, 6 days a week, power only, $57.00 per kilowatt year, or 0.792 cents per kilowatt hour for an engine plant, or about 8 per cent less for a turbine plant. If the waste products were used for manufacturing, these costs might be reduced by about one-third.

For use in industrial plants, 10 hours a day, 300 days a year, straight power would cost $32.00 per kilowatt year. If heating is done, by exhaust steam, these figures may be reduced by about $1.20 per kilowatt or to say $30.60 per kilowatt year. This would be about $23.00 per engine horse-power and $20.00 per indicated horse-power year.

For colored textile mills, making use of exhaust steam and water of condensation, the original cost of straight power would be the same as that given in the preceding paragraph. This may be reduced by using the exhaust steam and waste products by from $2.00 to $12.00 per kilowatt year, depending upon the amount of steam and waste products used.

The common price for hydro-electric power, 24 hours a day, 6 days a week, is from $30.00 to $40.00 per electrical horse-power or $40.00 to $53.50 per kilowatt.

The common price for hydro-electric power, 10 hours a day, 3,000 hours a year, is from $20.00 to $25 per electrical horse-power, or from $27.00 to $33.50 per kilowatt.—Machinery.

One hundred and fifty locomotives of the Lehigh Valley Railway are being equipped with a new fuel-saving device. On all locomotives the air brake pumps are operated by steam, and it has been the practice to conduct the exhaust steam from the pumps to the smoke-box, to which the stack is attached, and then to release it, causing a draught. Considerable work is done by the brake pumps when the locomotive is at a standstill, thus causing a needless loss of fuel. By the new arrangement the exhaust steam is carried outside instead of inside the smoke stacks. Tests made by the above-named railway show that the company is saving about 1,000 pounds of coal per locomotive on the descent of the bank from Glen Summit to Pennhaven Junction, Pa., a distance of 26 miles.

A WAVE-LENGTH COMPARATOR.*

STANDARD MEASUREMENT IN WAVE-LENGTHS OF LIGHT.

BY A. E. H. TUTTON.

THE employment of the principle of the interference of two rays of monochromatic light, derived from the same source, one retarded behind the other by having to traverse a longer path, for the production of rectilinear interference bands constituting a scale of half-wave-lengths, has now been brought to such perfection that this highly refined scale may be used for the measurement of short distances or small movements of any description whatsoever. The accuracy is absolute to the tenth part of a scale division, the twentieth part of a wave-length of light, and is actually measurable with the most ordinary micrometer to the one-hundredth of a scale division, corresponding to the two-hundredth part of a wave-length. Now a wave-length of even the grossest radiations employed, those of red light, derived from either cadmium vapor (0.0006438 millimeter) or hydrogen (0.0006562 millimeter), is a forty-thousandth of an inch, so that the measurable unit is an eight-millionth part of an inch.

The finest trustworthy measurement by mechanical means (such as the Whitworth machine) or micrometric devices (such as the most refined thickness measurer) is the one-thousandth of a millimeter, or the twenty-five-thousandth of an inch. Moreover, the amount of possible error with either of these mechanical methods of measurement or the interference method is from one to two units of the respective scales. Hence the interference method is only subject to a possible error of one three-hundred-and-twentieth the magnitude of that to which the mechanical mode of measurement is liable.

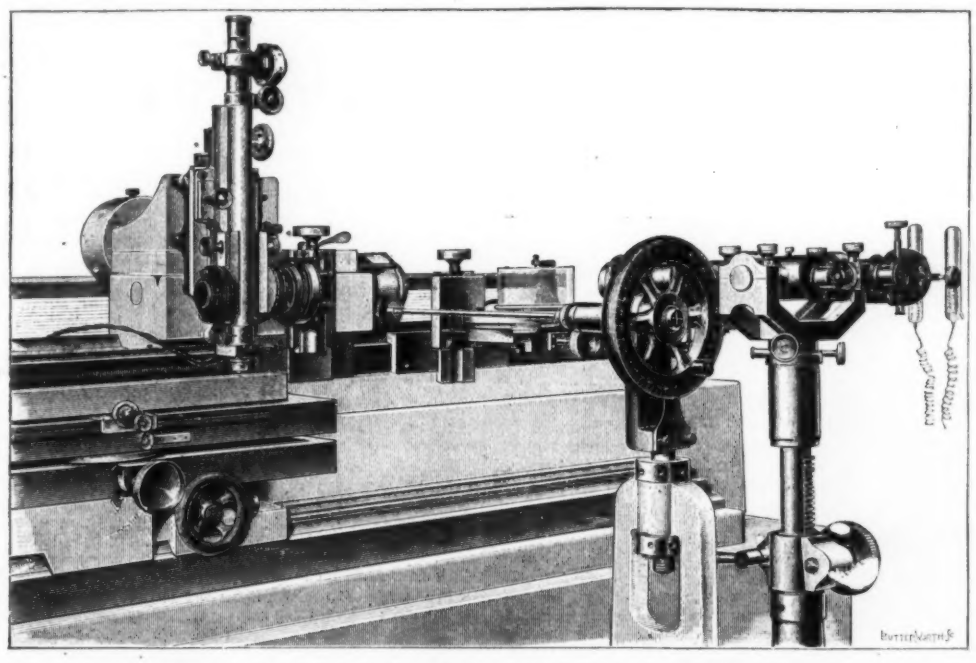
The interference method was first seriously employed by Fiezau, who utilized it for the determination of the thermal expansion of crystals and other small bodies. It was materially improved by Abbe and Pulfrich, and more recently both for the same crystallographic purpose and for general purposes by the writer, who has also extended its use to the measurement of the modulus of elasticity of crystals and small bodies or small quantities of substances in general.

It will be remembered also that Prof. Michelson, of Chicago, has recently adapted his entirely different mode of producing interference fringes, in this case circular, to the determination of the number of wave-lengths of red cadmium light, which he has proved to be the most homogenous of all radiations yet known to us, in the French meter. By employing a graduated series of glass-plate *étalons* or intermediate standards, each double of the preceding one, commencing with a basal one of half a millimeter in which the actual number (1,212) of half-wave-lengths was counted, the number of wave-lengths of red cadmium light in the meter was eventually found to be 1,553,163. This number has since been confirmed by the independent method of Fabry and Perot, in which circular fringes are also produced.

Three years ago the writer was invited by the Standards Department of the Board of Trade to adapt his interferometer to the purposes of a wave-length comparator of measures of length, and a memoir recently published in the Philosophical Transactions of the Royal Society (Phil. Trans. A, 1910, vol. ccx., p. 1), with the consent of the President of the Board of Trade, describes the instrument, which has now been installed in the Standards Office. The memoir also comprises an appendix concerning the possible employment of wave-length rulings on metal as defining lines on standard bars, with suggestions for their use along with the interference bands of the interferometer, in an original method of determining the total number of wave-lengths in the British yard.

A general view of the interferometer and one of the duplicate microscopes of the comparator, together with sufficient of the bar-carriage to enable some idea of the whole apparatus to be gained, is given in the accompanying illustration.

The whole instrument is mounted on a large stone block, resting on isolated concrete foundations. On a small stone pedestal, similarly isolated, in front of the large block, rests the pedestal of the auto-collimating telescope and attached Geissler tube of the interferometer. In the common focal plane of the telescope objective and eyepiece, opposite the junction of this main optical tube with the rectangularly attached side tube carrying the Geissler tube, a small totally reflecting prism is arranged, half covering the focal aperture. A still smaller rectangular stop or opening in a plate in front of and almost touching that one of the perpendicular prism faces which is directed toward the objective, and lies in the focal plane very close to the edge dividing the closed half from the open half, is the effective source of the interfering light; the rays from the Geissler tube, received on the other face of the right-angled prism, are arranged to fill this stop after reflection from the hypotenuse of the prism. The rays proceed from the stop to the objective, which they are arranged to fill with light, and thence pass out of the telescope as parallel rays, in the path of which the dispersion and interference apparatus is placed. The rays return to the telescope from the latter along practically the same path, but after re-entering the telescope, instead of returning to the little rectangular stop, their origin, they are deflected just sufficiently to one side to form an image of the stop, the same size as the original, in the open semi-circular aperture of the focal plane, within a couple of millimeters of the real stop. This closeness to identity of path of the outgoing and the incoming rays, and consequent normal incidence on the reflecting glass surfaces of the interference apparatus, is largely responsible for the magnificent field of parallel straight-lined interference bands which the author's interferometer affords, for it fulfills an essential condition for perfect interference.



CENTRAL PART OF COMPARATOR, SHOWING INTERFEROMETER.

With the ordinary eyepiece in position, the images of the stop reflected from the various surfaces of the interference apparatus can be focused, adequately magnified, and viewed during their adjustment to the theoretically ideal positions. But when this eyepiece is replaced by a special one consisting of a Ramsden micrometer combined with an additional lens between the latter and the focal plane, the telescope is converted into a low-power microscope, which focuses simultaneously the interference bands, a little silvered reference ring in the center of one of the two surfaces reflecting the interfering light, and the micrometer spider lines. There are two parallel vertical spider lines; one is adjustable by the left drum head of the micrometer, so as to be able to set it at any convenient distance from the other in order to include a single band and most of the reference ring between them; and both are moved together by the other (right) measuring drum, in order to be able to determine the band width and any fraction of a band which may have passed the reference center.

The dispersion apparatus consists of a Hilger constant-deviation prism, which enables the desired spectrum ray to be isolated from all others, and that alone delivered to the interference apparatus. The rays are deviated exactly at right angles by this prism toward the interference apparatus, the surfaces of which they strike at normal incidence, after which they return through the constant-deviation prism (thus securing double dispersion) to the telescope. The prism is mounted on a divided circle, so that it may be calibrated for the delivery of light of any desired wave-length, if desired, and has numerous adjustments Such calibration is not essential, however, as the particular image of the origin-stop in the color corresponding to the spectrum bright line of cadmium or hydrogen can be adjusted visually on removal of the front lenses of the Ramsden eyepiece.

The interference apparatus consists of three circular and thick glass disks, the third of which is of black glass polished an absolutely true plane on its outer surface, which is one of the two important surfaces concerned in the production of the interfering light. It is ground on the black surface, by which it is attached in an adjustable manner to the right microscope of the comparator, the movement of which it is to record. The other two are larger disks of colorless glass, identically similar, the two truly plane surfaces of each disk not being strictly parallel, but inclined at the minute angle of 35 minutes. The left surface of that one nearest to the black glass disk is the second surface concerned in the interference, and approaches the black glass within a millimeter; the second is a duplicate one, merely introduced on the right of it to correct for the slight dispersion produced by the 35 min. of inclination, the two being set oppositely as regards the direction of the wedge. The 35-min. inclination is just adequate to deflect out of the field of the telescope the reflection from the other (right) surface of the left colorless disk, and both images from the countervailing disk are got rid of by a slight tilt in the rectangular direction. All the many adjustments required are provided for in the mounting of the two colorless disks, on a separate carrier sliding along the face of the upper V-and-plane bed of the comparator.

The apparatus as described up to this point is the interferometer.

The comparator consists of two V-and-plane beds, nearly 7 feet long, of specially homogeneous cast iron, and worked truly plane with consummate care, together with their contents; they are arranged stepwise, one on the top of the stone block, and the other 7½ inches below and in front. On the upper one slide the two duplicate microscopes, and on the lower one the standard-bar carriage and accessory fine-adjustment fittings. The carriage is given a longitudinal motion, a transverse motion, adequate to bring either of the two bars to be compared under the microscopes, as well as fine adjustments for azimuth, height and level, thus enabling the defining marks on the bars to be readily focused without touching the microscopes if it is so desired.

Each microscope is carried on a solidly constructed slider on the V-and-plane bed, by which its coarse adjustment for position is effected. The microscope-bearing bracket is not, however, fixed directly to this slider, but to a second one sliding over the first, also with V-and-plane contact, and with the further control of the movement of a cylinder within a cylindri-

* Nature.

cal boring. The fine-sliding is effected by means of a most carefully made screw of fifty threads to the inch, on which the success of the instrument depends, and which carries at its outer end a large milled head for hand rotation, and a wormwheel of 100 teeth gearing with an endless screw, which can either be rotated by hand by means of a milled head or by means of a shaft and a large wheel seen in front in the illustration. One complete rotation of the latter corresponds to the movement of the microscope and the black glass interference disk to an extent which causes the passage of fifteen interference bands past the reference center. More than an inch of movement of the circumference of the wheel is necessary to effect the passage of a single band. Two-thirds of the dead weight of the microscope and slider are taken up by four spring pistons, and the movement of the slider by the screw is only a push in either direction against the walls of a recess in the free slider, there being absolutely no strain anywhere. Hence this movement of the microscope is not only an excessively fine one, but also so steady that the bands pass with a precision which leaves nothing to be desired, and each band may be held for any length of time for counting purposes.

Each microscope is provided with a micrometer eyepiece, with spider-lines arranged as in the interferometer. The fine adjustment is made exceptionally steady and regular. Two sets of objectives are provided, one pair for observing the defining lines in the countersunk wells near the ends of standard bars, with a magnification of 150 diameters, and without penetration of the well by the objective, and the other set for use with the wave-length rulings.

The defining lines, of whatever character, are illuminated (with "critical illumination") by the brilliant image of a distant Nernst lamp, with the aid in each case of a little reflecting prism, a collimating lens, an iris diaphragm, and a glass-plate mirror above the objective, all provided with fine adjustments. This avoids all heating effect on the bars, and the last traces of heat rays are filtered out by a thick water jacket in front of the lamp and its beam-parallelizing lenses. The illumination of the wave-length rulings one-forty-thousandth of an inch apart is excellent with the 1/12th-inch dry objectives employed, and the definition truly surprising.

The temperature of the whole comparator room is maintained at the official temperature, 62 deg. F., entirely electrically, both as regards artificial heating and the thermostat, which is original. So sensitive is the latter that the entrance of a person into the room is immediately followed by the extinction of one of the heating lamps to compensate for the extra warmth introduced.

The finest defining lines yet employed on any line-measure bars are those on the platinum-iridium copy of the imperial standard yard. Yet even each of these has a thickness equivalent to fifteen interference bands. The defining lines on the imperial yard itself are three times as coarse. Hence we have now arrived at that stage in the competition between defining lines and refinement of measurement when the latter has far surpassed the former. It was for this reason that the writer took up the investigation of wave-length rulings, with the idea of their possible use as defining lines commensurable with the increased refinement of measurement. Mr. H. J. Grayson, of Melbourne, whose wonderfully fine rulings have recently been much discussed in microscopic circles, has kindly made a number of rulings of 1/40,000th-inch fineness, which preliminary experiments indicated as feasible for the required purpose, on polished speculum-metal and platinum-iridium, which appear, particularly the former, perfectly satisfactory. The forty-thousandth of an inch being the wave-length of red hydrogen or cadmium light, the distance between two lines ruled at this interval corresponds to only two interference bands. With the 1/12th-inch dry objectives the lines, moreover, are as cleanly cut as spider lines, and the thicknesses of a line is less than half a wave-length. Five such lines are ruled in succession, the central one being considered as *the* defining line. A strong-finder line is ruled on each side of the five, and two other strong ones at right angles in order to localize a central part of such a system. It appears perfectly feasible to carry out a stepping-off process for the counting of the total number of wave-lengths of cadmium red light in the British yard, in which such rulings would take the place of the glass plates of the Michelson or Fabry and Perot *étalons*, a base line of the thirty-second part of an inch being first actually counted in bands with the aid of the interferometer, between limits defined by two such systems of rulings. The final fraction of every stage in such a process could be absolutely checked by the interferometer in all cases where Michelson found it possible to do so, that is, so far as interference bands are still visible, about four inches; and, as it has already been proved that the accuracy with the rulings is almost as great as with interference bands, this checking ceases to be as imperative as when only the coarse existing defining lines are available. Hence, the future before these rulings appears likely to be both interesting and important.

MENDELEEFF'S LIFE AND WORK.*

THE CAREER OF A GREAT CHEMIST.

Concluded from Supplement No. 1789, Page 251.

In March, 1869, Mendeléeff communicated to the Russian Chemical Society an enunciation of the principle of periodicity and a statement of some of the consequences of this recognition of the relation of properties to atomic weight throughout the whole range of the known elements, and this statement was accompanied by a table which, while it bears a close resemblance to Odling's table of 1864, was apparently connected in his mind with an idea which became clearer and more decisive in the modifications which he immediately afterwards introduced into the arrangement.

Mendeléeff's First Table of the Elements.

						Ti = 50	Zr = 90	? = 180
						V = 51	Nb = 94	Ta = 182
						Cr = 52	Mo = 96	W = 186
						Mn = 55	Rh = 104.4	Pt = 197.4
						Fe = 56	Ru = 104.4	Ir = 198
					Ni = Co	= 59	Pd = 106.6	Os = 199
H = 1					Cu	= 63.4	Ag = 108	Hg = 200
	Be	= 9.4	Mg	= 24	Zn	= 65.2	Cd = 112	
	B	= 11	Al	= 27.4	?	= 68	U = 116	Au = 197 ?
	C	= 12	Si	= 28	?	= 70	Sn = 118	
	N	= 14	P	= 31	As	= 75	Sb = 122	Bi = 210 ?
	O	= 16	S	= 32	Se	= 79.4	Te = 128 ?	
	F	= 19	Cl	= 35.5	Br	= 80	I = 127	
Li = 7	Na	= 23	K	= 39	Rb	= 85.4	Cs = 133	Tl = 204
			Ca	= 40	Sr	= 87.6	Ba = 137	Pb = 207.
			?	= 45	Ce	= 92		
			?Er	= 56	La	= 94		
			?Yt	= 60	Di	= 95		
			?In	= 75.6	Th	= 118		

From this arrangement, in which the elements are placed in vertical columns, according to increasing atomic weight, so that the horizontal lines contain analogous elements again according to increasing atomic weight, Mendeléeff deduced the fundamental principle which he expressed as follows: The elements arranged according to the magnitude of atomic weight show a periodic† change of properties.

Previous students of the subject had been, for the most part, struck with the relations obviously subsisting between the members of the several natural families of elements, but had, with few exceptions, failed to perceive that there must be a *general* law binding the whole together. However, Mendeléeff, with that noble sentiment of justice which always animates the truly scientific mind, admits that the idea of a general law had already been foreshadowed by others (Faraday lecture, 1889).

Mendeléeff's table of 1869 was subsequently in 1871 modified so as to assume the form with which we have all been so long familiar, and which is to be found in every modern text-book. Thus it may be claimed for Mendeléeff that he was actually the first, not only to formulate a general law connecting atomic weights with properties, but was the first to indicate its character, and, as he himself ("Principles," 1905, ii. p. 28) has pointed out, he was the first "to foretell the *properties of undiscovered* elements, or to alter the accepted atomic weights" in confidence of its validity. The time was, in fact, ripe for the enunciation of this general principle, and, the suggestion once given, the relations embodied in the law could not fail to attract other chemists. Accordingly, in December, 1869, Lothar Meyer, with such knowledge of Mendeléeff's scheme as could be derived from the imperfect German version of his paper of the previous March, proved himself a convinced exponent of the idea by contributing to Liebig's *Annalen* a paper containing a table, substantially identical with that of Mendeléeff, and his famous diagram of atomic volumes, which, more clearly even than the tabular scheme, illustrates the principle of periodicity.

The history of science shows many instances of the same kind. Great generalizations have often resulted from the gradual accumulation of facts which, after remaining for a time isolated or confused, have been found to admit of co-ordination into a comprehensive scheme, and, this once clearly formulated, many workers are found ready to assist in its development. The case is nearly parallel to the recognition of the operation of natural selection by Darwin and Wallace, or it might be compared to the discovery of oxygen by Priestley and Scheele and the utilization of this knowledge by Lavoisier. In each case much preparatory work has been done, and a body of knowledge had been gradually accumulated which, when duly marshaled and surveyed by the eye of a master, could scarcely fail to reveal to him the underlying principle. The full consequences, however, would appear only to a few.

I regard it unnecessary, in the presence of the fellows of the Chemical Society, to review with any detail the multitudinous applications of the scheme of the elements constructed on the basis of the periodic law. These are the commonplaces of modern theoretical chemistry. They are embodied in every text-book of any importance, and are related by every lecturer and teacher as familiar and indisputably recognized consequences of the system. We may, therefore, pass lightly over the story of the prediction by Mendeléeff of the properties of undiscovered elements, confirmed so remarkably by the discovery of scandium, gallium, and germanium, and related in dramatic language by Mendeléeff himself (Faraday lecture). We may also pass over the applications of the system to the correction of atomic weights, illustrated by the case of beryllium, the recognition of previously unnoticed relations, and the discovery of new elements, notably the companions of argon (Ramsay, Presidential Address to Section B, British Association, 1897, and Proc. Roy. Soc., 1898, lxiii., 437).

It will be more profitable to consider a few of the difficulties which still encumber the application of the law, and which, while limiting our acceptance of it in an unqualified form as applicable to the whole of the elements, tempt the speculative mind to wander in wide fields of conjecture.

Can it be truly said that the elements arranged in the order of their atomic weights show without exception periodic changes of properties? This question has been propounded already, but has never been fully discussed, even by Mendeléeff. An examination of the facts seems, however, to indicate the possibility of some other principle, which, while it does not supersede the periodic scheme, would, if it could be recognized, supplement it.

From a consideration of the almost unbroken sequence in the atomic weights of the known elements, it seems probable that few additional elements are to be expected, except possibly on following Mo and another following W, save in the region from Bi to Ra. This suggests the remark that, after all, it is not necessary to assume that the materials of which the earth consists should necessarily include a sample of every possible element indicated by such a scheme. Some which are missing from terrestrial matters may perhaps be responsible for phenomena recognizable by the spectroscope in stars or nebulæ far distant in cosmical space. The unexpected, however, often happens, and, remembering the discovery of terrestrial helium, it is permissible to hope that some of the vacant spaces may hereafter be filled by earthly occupants.

There is one important point to be noted here, namely, that if the so-called rare earth metals, praseodymium, neodymium, samarium, gadolinium, terbium, dysprosium, erbium, ytterbium, and others of which the existence is doubtful, do lie in the position indicated, the original statement of the periodic law breaks down at this point.

One result of the recognition of the periodic law is that theories concerning the genesis of the elements have received a stimulus previously unknown. It is, however, interesting to note the attitude of Mendeléeff toward this question, and the small extent to which this attitude appears to have become modified with the lapse of time. When, in 1889, twenty years after the discovery of the law, he composed the Faraday lecture, he seems to have regarded speculation in this direction as a kind of abuse of the periodic system.

Fifteen years later, after the discovery of the argon group of elements, of the phenomena of radio activity, and of radium, it became necessary to consider the relations of these substances to the periodic scheme. In a remarkable article contributed to the new Russian

* The Mendeléeff Memorial Lecture delivered before the Chemical Society on October 21, 1909, by Sir William A. Tilden, F.R.S. Abridged from the Journal of the Society for December, 1909.

† Here an error in the German translation does an injustice to the original, inasmuch as the Russian word for periodic is rendered "stufenweise" (gradual).

Encyclopædia, and subsequently printed as Appendix iii. to the "Principles" (English edition, 1905), Mendeléeff gives a new table of the elements, in which places are found, not only for the argon group and radium, but for two hypothetical elements, which are placed before helium and designated *x* and *y*.

The *y* in the table is supposed to be an analogue of helium, and may be identified hereafter with "coronium," which has been recognized in the sun's coronal atmosphere. This gas would have, according to Mendeléeff, a density about 0.2, and, therefore, a molecular weight about 0.4, or about one-tenth that of helium.

x is the "ether" of the physicist, for which Mendeléeff, disregarding conventional views, supposes a molecular structure. He also assumes that, like the argon group, this element is chemically inert and possesses a very low density and atomic weight, estimated at 0.000,000,000,053.

Chemists and physicists have, however, found it impossible to resist the fascination of this problem, and accordingly there have been many hypotheses as to the original of the elements and the nature of their connection with one another. These seem to be inseparable from the periodic scheme itself, which at once provokes the inquiry: Why do these numerical relations occur, and what is the meaning of them if they do not point to a common genesis or the operation of some process of evolution?

Hypotheses concerning the evolution of the elements have hitherto been usually based on the assumption that the successive stages of condensation of elemental matter proceed from a single primary stuff, which by a process analogous to polymerization among carbon compounds gave rise to atoms of greater and greater mass, which were stable at the prevailing and any low temperature. The physical cause of the successive condensations is supposed to be a falling temperature. It is, of course, possible to imagine that if to the stuff of which hydrogen atoms consist are added successive portions of matter of the same kind, stable structures may at intervals result which we know as the atoms of the elements helium, lithium, beryllium, boron, carbon, nitrogen, oxygen, and fluorine, provided the idea of internal structure in these atoms is allowed. Otherwise, from the mere accretion of matter upon a central nucleus, there seems no sufficient reason why there should not have been formed an indefinite number of intermediate masses corresponding to an indefinite number of what would be called elements. Further, it is difficult to understand why simple increase of mass should change, say, oxygen into fluorine, while a further addition of the same kind should change negative flourine into inert neon or positive sodium. The possibility of the condensation of a single "protyl" so as to produce, at successive though unequal stages of cooling, the elements known to the chemist, has been most ably discussed long ago by Sir William Crookes.

This hypothesis, however, was put forward long before the work of Sir J. J. Thomson and his school was given to the world and the electron was accepted as a physical reality. The hypothesis that one elemental stuff may give rise to the whole array of known elements by a process of condensation accompanied by a loss or gain of electrons, the mass of which is approximately one-thousandth of the mass of an atom of hydrogen, forms the subject of a paper by Mr. A. C. G. Egerton in a recent number of our Transactions (1909, xcv., 239). The atomic weights calculated by his formula agree closely with the experimental atomic weights of the first fifteen elements, but the hypothesis gives no explanation of the facts observed in the physical properties of the elements arranged according to the Mendeléeff scheme, their alternation of odd and even valency, the transition from positive on one side of the table to negative on the other, the periodicity of properties shown by the sudden change of character in passing from fluorine to the next element, whether it be neon or sodium.

Another paper by Messrs. A. C. and A. E. Jessup (Phil. Mag., 1908 [vi.], xv., 21) has recently provided a hypothesis of an entirely different character. From a study of the spectra of the nebulæ, these authors have been led to assume the existence of two hitherto unrecognized elements, to which the names protoglucinum and protoboron are assigned. These with hydrogen and helium are supposed to represent *four* initial substances, or protons, which, by condensation directly or indirectly, give rise to all the rest of the elements. The arguments of these authors are ingenious, but rather artificial in view of the fact that the number of groups in the periodic scheme to be provided for is greater than four.

In the Mendeléeff chart of the elements there is nothing more striking than the gathering of the negative elements toward what may be called the N.E., and the segregation of the positive elements toward the S.W., the center of the intermediate territory being occupied by elements which play a more or less undecided part. I have elsewhere (Presidential Address, 1905, Trans., lxxxvii., 564) directed attention to the fact that carbon, at any rate, is not directly deposited by electrolysis from any of its compounds, with positive hydrogen on the one hand, or negative chlorine on the other. I believe the same is true of silicon, these two elements standing in a middle position between the extremes occupied by lithium and fluorine respectively.

If we assume that atoms are made up of two parts (protyls), positive and negative, in proportions which determine by the preponderance of one or the other whether the element shall exhibit the positive character of a metal like lithium or the negative character of a halogen, we arrive at a hypothesis which recalls the ideas put forward nearly a century ago by Berzelius. His views are familiar to every student of the history of chemistry, but have long been relegated to the lumber-room of worn-out doctrine. The last few years have, however, given us the remarkable experimental investigations of J. J. Thomson already referred to, and the new conceptions concerning the nature of atoms, which revive the fundamental idea that they are made up of two components.*

Setting out the known elements in the order of the numerical value of their atomic weights, we find that between the first three elements, H = 1, He = 4, and Li = 7, the difference, 3, is greater than would be expected by comparison with the difference noticed between the elements of greater atomic weight which immediately follow them. In order to satisfy the hypothesis just put forward, there appears to be wanting an element which should stand in the same relation to fluorine as hydrogen to lithium. This would have an atomic weight 2-7 approximately. Whether this exists, and whether its existence is indicated by the unappropriated spectral lines of nebulæ or corona, can only be a matter of conjecture. Mendeléeff, in his (1905) latest speculations concerning the possibility of still undiscovered elements, has suggested the existence of a new element of the halogen group with an atomic weight about;† but, as already sufficiently shown, he accepted no hypothesis which involved any idea of the composite nature of the elements. It would, therefore, have been foreign to his system to employ this element in any such manner.

The conceptions presented to us in J. J. Thomson's work permit of several supplementary hypotheses, especially the idea that if atoms are really made up of smaller corpuscles these are not thrown together in confusion, but, as he has shown, must be distributed within the mass in a definite order, which is determined by the attraction of the electro-positive shell and the self-repulsion of the negative corpuscles included in it. Once the idea of structure within the atom is admitted, the possibility presents itself of there being for the same mass more than one arrangement corresponding to what is called isomerism in compounds.

I have dwelt at some length on these various hypotheses, because the discussion of the subject to which they relate indicates, in my opinion, one of the consequences of the promulgation and general acceptance of the periodic scheme of the elements. This is, however, not the only result of the recognition of its validity and usefulness by chemists generally. That the elements stand in a definite relation to one another implies that their compounds also fall into their places in an orderly system, and consequently a basis is provided for the complete systematization of the whole science of chemistry. There is scarcely a treatise on chemistry which does not bear evident witness to this influence; and this is perhaps not the least among the services rendered by this generalization, for not only is the learner enabled to remember a much larger number of facts than previously, but he is led to perceive a connection between phenomena and processes which was almost entirely wanting so long as practical chemistry consisted mainly of a bundle of recipes. Here it is fitting that we should glance at the famous treatise by Mendeléeff himself, "The Principles of Chemistry," of which we possess three editions in English, the last of which, issued in 1905, is a rendering of the seventh edition (1903) of the original. An eighth Russian edition began to be issued in 1905, but is incomplete. To this remarkable book it is impossible to do justice in a brief notice or to communicate to those who have not read it an adequate impression. Clearly it is a work of genius, but such works are not always the most suitable for beginners, though for the advanced student nothing can be more inspiring. The "Principles" embody in reality two distinct treatises, for the text, which is written in an easy style, open to quite straightforward reading, is accompanied by notes which are often more voluminous and usurp entire pages. Even the preface is attended by these commentaries, which are all interesting as showing the spirit of the writer and the restless activity of his mind.

Little more remains to be said. In the seventeenth century Robert Boyle taught us how to distinguish elements from compounds, and how to give the word "element" a definite connotation clearly distinguishing it from the elusive and fantastic language of the alchemists. In the eighteenth century Lavoisier showed the true nature of the most familiar of chemical compounds, namely, acids, bases, and salts, and helped to lay the foundation of quantitative chemistry. At the beginning of the nineteenth century Dalton gave to chemistry the atomic theory, of which it is not too much to say that it provided the scaffold by the aid of which the entire fabric of modern theoretical chemistry has been built up. Sixty years later this conception, developed and adorned by the labors of an army of earnest workers, has been shown to us in a brilliant new light thrown over the whole theory by Mendeléeff.

The views of Boyle, of Lavoisier, and of Dalton have been corrected by experience and broadened by extended knowledge, but the fundamental and essential parts of their ideas remain, and their names are immortal. In like manner the expression of the periodic law of the elements as known to the present generation is destined, we may believe, to be absorbed into a more compresensive scheme by which obscurities and anomalies will be cleared away, the true relations of all the elements to one another revealed, and doubts as to the doctrine of evolution resolved in one sense or the other; but as with the atomic theory itself, there is no reason to doubt that the essential features of the periodic scheme will be clearly distinguished through all time, and in association with it the name of Mendeléeff will be for ever preserved among the fathers or founders of chemistry.

In an article published in the Z. physik. Chem., A. Coehn and H. Becker describe some investigations of the photochemistry of sulphuric acid. The authors studied the formation of sulphur trioxide from sulphur dioxide and oxygen under the influence of the radiation from a quartz mercury lamp. Experiments made with a quartz reaction vessel mounted within a mercury lamp showed that the formation of sulphur trioxide proceeds fairly rapidly even at the ordinary temperature and more rapidly at higher temperatures. The equilibrium is quite distinct from that attained in daylight. With the mixture, $2SO_2 : O_2$, equilibrium is attained with a production of 65 per cent of sulphur trioxide, and this equilibrium can also be attained starting from sulphur trioxide. At 160 deg. C., with the gases confined in the reaction chamber, equilibrium was attained in 1 hour. In daylight at temperatures below 450 deg. C. the equilibrium condition corresponds with practically 100 per cent of sulphur trioxide. Again the light-equilibrium (attained on exposure to the radiation from the mercury damp) is not displaced by a rise of temperature up to 800 deg. C., whereas the temperature of dark-equilibrium (in daylight) is displaced considerably by a rise of temperature above 450 deg. C. With a mixture in the proportions, $SO_2 : O_2 = 1 : 13$, for example, at 800 deg. C., the yield of sulphur trioxide is 80 per cent on exposure to the rays from the mercury lamp, whereas in daylight, the yield is 44 per cent of sulphur trioxide. The temperature coefficient of the velocity of the photochemical reaction was found to be 1.2. The authors consider that a technical photochemical process for the production of sulphuric acid is quite feasible, since on using air in place of oxygen, no oxides of nitrogen are formed. Some experiments were made with a special mercury lamp composed essentially of a quartz tube, 115 centimeters long and 1.8 centimeter diameter. This was inclosed in a tube of opaque, English quartz, 100 centimeters long and 5 centimeters diameter, the annular space between the two serving as a reaction chamber. At 450 deg. C. and with the gaseous mixture passing at the rate of 100 to 150 cubic centimeters per minute, yields of 67.4, 70.8, 92, and 90 per cent respectively of sulphur trioxide were obtained, with 0.78, 0.66, 8.7, and 9.3 molecules of oxygen per molecule of sulphur dioxide.

The State railway from Magdeburg to Halle, *via* Zerbst and Leipzig, states the Electrical Engineer, will soon be electrified throughout its entire length, and also the branch line from Dessau to Bilterfeld, which is about 16 miles long. The total length of the line between Magdeburg and Halle is about 96 miles. It taps all the important brown coal fields in the neighborhood of Mulde, which urgently require better and cheaper means of transport. The power will be provided by a station at the small Prussian village of Muldenstein, which has been selected because brown coal for fuel is abundant there. The current used for the electric locomotives will be a high-tension alternating current, supplied at 10,000 volts. The whole cost will exceed one million sterling, at all events, but it is said that it may be considerably more.

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* Carnelley, in 1885 (Brit. Assoc. Reports), brought forward the idea "that the elements are not elements in the strict sense of the term, but are, in fact, compound radicals made up of at least two simple elements, A and B." The element A was supposed to be identical with carbon, while to B was assigned a negative weight, —2, and it was suggested that it might be the ether of space. C. S. Palmer (Prof. Colorado Scient. Soc.) assumed the existence of two sub-elements, to which he gave the names "kalidium" and "oxidium," and his views appear to have a general resemblance to the hypothesis suggested in the text. The original article is abstracted in Venable's "Periodic Law," and is referred to in footnotes in Palmer's translation of Nernst's "Theoretical Chemistry."

† It may also, perhaps, be worthy of note that Mr. Egerton's calculations (*loc. cit.*) lead him to postulate an element of nearly this atomic weight, namely, 2.9844, although his paper gives no indication as to its character.

ELEVATORS.

AT Hamburg there has been recently constructed a tunnel which runs under an arm of the Elbe River, and it thus serves to connect two different quarters of the city. The tunnel is formed of two parallel tubes placed nearly horizontal and having 6 meters (19.7 feet) diameter. A point which is worthy of notice here is that vertical shafts and elevators are used at the ends of the tunnel in place of the usual inclined access. There are used two shafts of 22 meters (72.2 feet) diameter and about 25 meters (82 feet) in depth. In each of the shafts there are staircases and also six electric elevators. Two of these are placed in the middle of the shaft, and are designed to take a load of 10 tons. They serve to lift the heavy vehicles, while there are also provided two smaller elevators of the 2-ton type. Each elevator cabin is balanced at half the normal load by a counterweight, so that the motors are designed of such size as is needed to lift the additional half load. Direct current electric motors are used here, and each of the large elevators has two motors, while one motor serves for the small ones. The motors drive the cables by means of endless screw transmission. The motors have different field windings, and the circuits of these latter are combined in different ways, according to the working of the elevator (starting, braking, etc.) by an automatic contact system. A well designed series of safety appliances complete the apparatus.

ALCOHOL IN INTERNAL COMBUSTION ENGINES.

A PAPER was recently read before the Canadian Society of Civil Engineers by G. L. Guillet on the use of alcohol in internal combustion engines. From this paper we gather that, although methyl alcohol (C_2H_5OH) has a heat of combustion of only 10,000 B.Th.U. per lb., or 5500 kg.-cals. per kg., against gasoline (or coal oil) at 19,000 B.Th.U. per lb., or 10,500 kg.-cals. per kg., yet for complete combustion 1 kg. alcohol requires only 6.616 m.³ of air, while 1 kg. gasoline requires 12.83 m.³. This enables an engine cylinder of fixed dimensions, say 10 liters, to develop more power from alcohol. Thus, in 10 liters of air we can burn $10/6.616 = 1.52$ gm. alcohol, or $10/12.83 = 0.779$ gm. gasoline; or the heat generated would be, for alcohol, $1.52 \times (1000/5500) = 8.36$ kg.-cals.; for gasoline $0.799 \times (10{,}500/1000) = 8.18$ kg.-cals. The vapor pressures of these liquids throw light upon the question of their vaporization or comparative facility for being carbureted. In the following table the figures for gasoline are approximately correct on account of variation in quality. Ethyl alcohol (CH_3OH)

Temperature, Deg. Fahr.	Vapor Pressure of Saturation in Millimeters of Mercury.			
	Pure Ethyl Alcohol	Pure Methyl Alcohol.	Water.	Gasoline.
50	24	54	9	133
68	44	94	17	179
86	78	159	32	251
104	134	259	55	360
122	220	400	92	493
140	350	601	149	648

is added for comparison. The engine used was a "Blackstone" oil engine rated at 4 horse-power, with 5 in. diameter of cylinder, 10.875-in. stroke, running at 260 revolutions per minute, installed in the Mechanical Laboratory at McGill University. For oil fuel, the engine had hot-tube ignition, "hit and miss," regulation, with centrifugal governor, and a screw adjustment for regulating gas-valve lift by which the quantity of fuel was determined. For alcohol, electric sparking plug ignition, the plug being placed in the current of the gases to the cylinder, was substituted, and a larger fuel nozzle with needle valve-adjustment was supplied. Brake tests were made with prime Canadian white oil, having calorific value of 19,700 B.Th.U. per lb. on the higher scale, and 18,600 B.Th.U. per lb. on the lower, and having a sp. gr. of 0.802. Wood alcohol of 0.812 sp. gr. gave by Junker calorimeter test 9400 B.Th.U., and 8700 B.Th.U. per lb. on the higher and lower scales, and denatured or methylated spirit of 92.07 per cent pure alcohol, and 0.817 sp. gr. gave 10,500 B.Th.U., and 9900 B.Th.U. per lb. on higher and lower calorific values. Numerous tests were made with these fuels, the results of which are set out in two long tables, and many indicator diagrams.

Curves show that the engine used over double the weight of alcohol compared with coal oil for the same brake horse-power, thus making fuel consumptions for equal over-all thermal efficiencies in the same ratio. Slightly less power was obtained with alcohol on full load. Igniter and vaporizers worked quite satisfactorily, but the air-valve had to be kept almost wholly closed. The engine would not run properly on methylated spirit. The chief drawback to alcohol as a fuel is its comparative cost where duty is charged.

ENGINEERING NOTES.

The increasing interest in the mineral products of the Western States, especially those lying in or west of what may be broadly termed the Rocky Mountain region, is reflected in the large measure of attention given to that region by the Geological Survey, which for several years has issued, under the title "Contributions to economic geology," annual volumes devoted largely to the mineral resources of that part of the country. The latest volume of this series (Bulletin 380) contains a number of valuable papers, discussing gold, silver, cement, and iron in Colorado; gold, silver, copper, and asphaltite in Nevada; gold and silver in Oregon; lead, zinc, and iron in New Mexico; wolframite and marble in Arizona; and other lesser deposits.

Paris stands 226 miles above the mouth of the Seine, measured along its course, and the area drained by the river above the city is only about 17,600 square miles. The mean discharge of the Seine at Paris is about 9,000 cubic feet per second (or, as engineers phrase it, "second-feet"); its greatest discharge in the flood of 1876 was 58,600 second-feet, its discharge at the height of the recent flood (January 27th, 1910) is reported to have been 83,500 second-feet. This is less than one-eighth the flood flow of the Susquehanna in 1889 (720,000 second-feet) and less than one-fifth the flood flow of the Potomac at Washington in the same year (470,000 second-feet), when boats were paddled along Pennsylvania Avenue, in the heart of the city.

A contribution to the study of phosphor bronze has been made by O. F. Hudson and E. F. Law. They point out that in alloys containing less than about 4.5 per cent of tin, the phosphorus is present as rounded, more or less detached particles of copper phosphide, Cu_3P, the tin being in solution in the copper. With more than about 4.5 per cent of tin, the alloys contain in addition a ternary eutectic of copper, Cu_3P, and Cu_3Sn, which has the composition 81 per cent of copper, 14.2 per cent of tin and 4.8 per cent of phosphorus, its melting point being 620° C. Copper is capable of holding a small quantity of phosphorus as tin in solution, and in the malleable phosphor bronzes in which tin does not exceed about 6 per cent and phosphorus 0.3 per cent., the phosphorus is present mainly in this state. In the cast phosphor bronzes which may contain as much as 12 per cent of tin and 1.5 per cent of phosphorus, the ternary eutectic is an essential constituent.

Some of the Paris newspapers have deplored what they have called the exaggerated foreign accounts of the flood, but no complete or trustworthy estimate of the damage done has yet been made. The Economiste Français says: "It is desirable to challenge many of the statements that have appeared to the effect that the national wealth has been seriously diminished and that it will be necessary to contract large public loans to cover the expenditures involved." M. René Tavernier, engineer of the French Department of Public Works (Ponts et Chaussies), writes to M. O. Leighton, chief hydrographer of the Geological Survey: "No bridge has been seriously damaged. The underground works, the sewers, and the tunnels of the Metropolitan Railway have in general withstood the flood perfectly, despite the abnormal pressure to which they have been subjected by the encroachment of the water. The damage, so far as public works are concerned, affects principally the docks, excavations, and unfinished works." The details of the several projects proposed to prevent future overflows of the Seine at Paris will be studied with general interest when they become available.

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TRADE NOTES AND FORMULÆ.

Chocolate and Marzipan (Marchpan) Glaze.—For coating chocolates and marzipan, so-called "confectioner's varnish" is usually employed. It is made from gum sandarac 125 parts, benzoin 125 parts, Venice turpentine 10 parts, and alcohol 740 parts.

Cedar Wood Odor Imitated.—Sandal oil is dissolved in absolute or strong alcohol and with the solution a wood resembling cedar in grain, such as willow or poplar, is painted or saturated. Finally a little Vesuvine (Bismarck brown) may be added.

For Preparing Celluloid Dishes.—A mixture of 1 parts of alcohol and 4 parts of ether is recommended. The fracture surfaces are painted with this, and on softening are pressed together. The same purpose, according to another recipe by L. E. Andrés, is effected by the following solutions: 1 part camphor, 5 parts shellac, 20 parts alcohol, or 1 part camphor, 1.5 part shellac, and 30 parts alcohol.

Glazing for Bottle Tops.—A bottle lac of this description is made simply by melting 1 part shellac, taking it from the fire and stirring in, for red, 2/5 part red lead; for green, ¼ part Russian green; yellow, 1/6 part chrome yellow; blue, ½ part ultramarine blue. In the mixture, while hot, the bottle tops are quickly dipped, regularly turned, and a fine, brilliant coating is obtained, using very little.

White Cement (according to O. Fahnejelen).—75 parts pure washed chalk and 25 parts of washed kaolin, calcined at a bright red heat and afterward ground, give a snow-white powder. This cement alone, or mixed with a small percentage of gypsum, makes an excellent hydraulic mortar, which hardens under water and after seven days attains a solidity of 6 to 10 kilos to 1 square centimeter. After three months it shows a strength of 25.5 kilos per square centimeter.

Pompeian Mosaic may be imitated with the aid of metallic cements, made from zinc compounds, lead oxide, magnesia cement, etc. The cement is prepared in the form of a thin paste and mixed with fragments of marble, lapis lazuli, malachite, etc., in the proportion of 1 to 1½ to 20. To the roughened, moistened surface, one color adjoining the other is applied, according to the pattern, and the whole placed under pressure. The hardened surface is cut and polished. The outlines of decorations may be reserved with stencils and then inlaid.

Chartreuse Liqueur (according to French directions).—

	Green. Parts.	Yellow. Parts.	White. Parts.
Iva herb	250	125	125
Alve	...	25	...
Angelica seed	125	125	125
Angelica root	60	125	30
Arrica blossoms	15	15	...
Balsamite balsam	150	...	...
Calamus	...	...	30
Ceylon cinnamon	15	15	100
Cardamoms, Malabar	...	30	30
Coriander	...	15,000	...
Tonka bean	...	...	10
Cloves	...	15	30
Hyssop	300	150	125
Mace	20	15	30
Nutmeg	...	...	15
Poplar buds	20	...	...
Common balm	500	250	125
Peppermint	250	...	...
Thyme	30	...	...

Digest for 24 to 36 hours, with 10,000 parts 95 per cent alcohol and 5,000 parts of water. Then distill off as much as possible and again rectify the distillate. The green and yellow Chartreuse are kept at an alcoholic strength of about 40 per cent, by adding to the distillate 32,000 parts of best (85 per cent) alcohol. Sweeten with 25,000 parts of boiled sugar and make up with water to 100,000 parts. White Chartreuse is kept at about 45 per cent by adding 37,000 parts of 95 per cent alcohol, sweetening with 35,000 parts of sugar, and making up to 100,000 parts.

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